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Making PPPs Work in Developing Countries: Overcoming Common Challenges

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Abstract
Public private partnership (PPP) has emerged as a more acceptable and beneficial alternative to privatization. Furthermore, the special mind-sets and specific skill-sets needed for successful PPPs are now impacting on the development of construction industries the world over. While their benefits may seem apparent, and of great promise to developing countries in particular, PPP projects present major challenges which, if not adequately addressed, may undermine their very purpose and also lead to a distortion of public sector priorities when choosing which infrastructure to develop. The paper explores these challenges and the implications for developing countries. It also provides an overview of a framework for a Decision Support System (DSS) designed to address the shortfalls in reliable knowledge about when (under what conditions) and how (in what form) PPPs should be mobilised. The DSS framework is being developed as part of an ongoing R&D project that aims to help public procuring agents achieve 'value for money' in PPP projects by (1) assisting in 'better value' decisions on the 'PPP-iability' of proposed projects and (2) providing a means for the live capture, codification and quick transfer of experiential knowledge.

Keywords
Decision Support System, developing countries, Hong Kong; PPP, public private partnership

INTRODUCTION

Whether for developed economies eager to transfer some of the traditional risks in, or to bring commercial reality to public ownership of assets; or for developing economies constrained by funding shortfalls in the provision of much needed public services, PPPs have emerged as more viable alternatives to privatisation. While the concept itself is not new, recent developments in the use of PPPs by some industrialised countries, especially the US, UK and Australia, have demonstrated the benefits and viability of such schemes and greatly revolutionised the concept of public service delivery. However, the successful use of PPPs is by no means straightforward. The experiences of these developed economies have also identified major issues and challenges that confront PPPs and which lie at the heart of the value for money debate. For many developing economies, PPPs have opened a window of opportunity for delivering needed public services where previously there was none, but the full knowledge of the challenges of PPPs and of the means to

overcome them, will very well determine whether they become realities in these countries or remain mere rhetoric.
This paper presents work in progress, which aims to provide useful knowledge about the challenges (and means of combating them), when and how to mobilise PPPs, within a DSS framework to assist decision making by procuring agents in Hong Kong. Such a framework has been suggested in many studies [e.g. [Zhang and Kumaraswamy 2001] The initial information for the framework is obtained through an extensive and critical review of the literature on PPPs in both developed and developing economies. Despite the special focus on Hong Kong, the framework proposed in this paper is considered useful in comparable scenarios in other developing countries. The paper starts with a definition of construction PPPs. The role of PPPs and trends in their development and use are then discussed. Some major challenges of PPPs are explored. An overview of the proposed framework is then presented along with indications on the next steps in its development, followed by some concluding remarks.

CONSTRUCTION PPPs - A DEFINITION

PPPs exist in various shades and forms so that they almost defy formal definition. Any collaboration between the public and private sector tends to be called a public private partnership. Li and Akintoye [Li and Akintoye 2003] explore the contradictory definitions of PPP. While some conceive of PPP as anything on a continuum between outsourcing of public services and full privatisation, others see PPP as a successor to privatisation and yet some view it as a viable alternative to privatisation. Because of the all-inclusive nature of PPP as a concept, many researchers and practitioners either avoid defining it or instead provide some defining features of PPPs. Our conceptualisation of PPPs is that they refer to the whole spectrum of collaborative arrangements between public and private sector entities other than public sector ownership/ outsourcing and privatisation. This conceptualisation of PPPs is thus that which leads to genuine risk transfer to the private sector and creates a shared responsibility for service outcomes, but without the complete loss of control by the public sector entity. However, this conceptualisation is equally too broad (if not vague) and encompasses projects/ programmes outside of the realm of construction. We define construction broadly, and in line with Eaton *et al.'s* [Eaton *et al.* 2005], as involving the planning, construction, and/ or maintenance of fixed structures as they relate to earth, water, or civilisation and their processes, as well as all the professionals involved. This paper thus defines a construction PPP as a PPP that has a substantial 'construction' component.

ROLE OF PPPs IN SERVICE PROVISION

The principal reasons for the use of PPPs by most governments have been to (1) overcome financial constraints in the provision of much needed public infrastructure services and (2) harness the private sector's efficiency and management expertise [HM Treasury 1993]. A project's suitability as a PPP thus depends on its commercial viability (i.e. its ability to pay for itself) and the scope of public benefit it offers. Free-standing projects that demonstrate a positive social benefit are procured through the BOOT/ PFI route. Frequently, however, many of the projects that principals wish to pursue are not financially robust enough to be procured by total private finance. The principal, usually a government or government department, will thus need to intervene to mitigate the risks sufficiently to make the projects financially attractive to the private sector. Trends in the development and use of PPPs can be broadly classified under two generations – first and second generation PPPs.

First generation PPPs have largely been pilot projects carefully selected to demonstrate the benefits of PPP as a procurement route. These have come with the necessary legislative changes, evolution of public sector study groups, task forces and steering groups. The projects taken forward have been free-standing in nature and with easily measurable performance outputs - typically power plants and transportation projects, including tunnels [Akintoye *et al.* 2005, Albouy and Bousba 1998, Duffield 2005, Zhang and Kumaraswamy 2001]. The main drivers for first generation PPPs have been limitations on traditional public funding of infrastructure services created by budget deficits or regulations on government borrowing (e.g. in EU countries). The off-balance sheet nature of these free-standing PPPs thus provided a way around these difficulties. In many of these situations, the notion of a Public Sector Comparator (PSC) was thus meaningless and/or the computation was not rigorous enough.

Second generation projects have involved the wider application of the PPP model and its extension to include education, healthcare, custodial, defence, courts and highway maintenance schemes. The operation/provision of the service is however carried out by the public sector. The private sector is paid a performance-adjusted unitary service fee for creating and/or maintaining an asset. The private sector controls typically about 10-15% of the total investment in the service provision. Second generation PPPs are based on the verifiable VfM achievable and have largely involved a rigorous and complex computation of the PSC. These have led to much higher transaction and bidding costs and many private sector partners have argued that their limited scope of involvement, coupled with the high bidding costs, does not justify any significant investment in innovation and in extreme cases, their participation in the proposed schemes [Akintoye *et al.* 2005, Curnow *et al.* 2005].

MAJOR ISSUES AND CHALLENGES OF PPPs

PPPs present enormous challenges to the construction industries of developing economies. These challenges are explored in the context of the wider issues in construction industry development as outlined in Ofori [Ofori 1993, 1994, 2000]. There are concerns about the exclusion of local and small-scale construction firms as only a handful of multinationals dominate every aspect of a PPP project [Hunter and Kelly 2005]. The 'big' players, who are capable of financing their own construction budgets, drive the campaign on PPPs in a manner that may further strengthen entry barriers to the PPP project market [Akintoye *et al.* 2005] . The tendency for public agencies to bundle smaller projects into sizable chunks so they can be let through the PPP route, as in the 'Building Schools for the Future' projects in the UK [Steadman 2005], may further worsen the impact on local construction industries. Indeed, this contrasts sharply with trends in developing economies where projects are split into smaller packages/ lots so they can be let to small scale contractors [Kumaraswamy 1994]. There is also a potential risk of such a trend resulting in a distortion of public sector development priorities, as only projects capable of being let through the PPP framework will be taken forward [Hall 1998].

In many developing countries, the huge backlog of demand for, and increasing shortfalls in the supply of, public services is largely due to financial constraints and limits on government borrowing/ spending demanded by fiscal reforms. As a direct consequence of these fiscal constraints and the relatively weak or non-existent local capital markets, many PPPs in developing countries involve huge foreign investment or concessionary loan finance, and tend to be restricted to free-standing (i.e. first generation) projects. These projects have typically included port facilities, power plants and highway schemes [Albouy and Bousba 1998, Harris 2003]. While presenting mixed opportunities for construction industry development [Ofori 1994], these conditions also limit the practical scope of application of PPPs in many developing countries. The high transaction and bidding costs are significant factors that stifle competition in, and create entry barriers into, the PPP market [Robinson *et al.* 2004, Tiffin and Hall 1998]. The special skill sets required for, and the steep learning curve involved in, construction PPPs have also been highlighted as hampering the development of a credible and sustainable market for PPPs and limiting the achievable VfM in such schemes [Akintoye *et al.* 2005, Duffield 2005, Robinson *et al.* 2004]. A classic outcome of such a situation is the 'catch-22' paradox where local construction firms in developing countries cannot win PPP contracts because they lack the necessary track record, while the only way they can obtain such a track record is by actually participating in PPP projects. For the public sector agencies involved, the use of PPP schemes could potentially lead to a lack or loss of asset knowledge and track record and thus greatly affecting the regulatory oversight of schemes.

In spite of these challenges, PPPs are thought to be particularly suitable for developing countries [Merna 2002]. S.O. Ogunlana in his paper presentation at a PPP conference in Hong Kong in February 2005 was succinct in his reference to PPP investments in developing countries as 'gold digging in partially cleared minefields' [Ogunlana 2005]. The best strategy then is that which extracts and delivers the gold while avoiding the mines. This involves addressing the major limitations and criticisms of PPPs. Albouy and Bousba [Albouy and Bousba 1998] suggest that transaction costs could be minimised by standardising documents where possible. However, the challenges faced in standardising documents are many given the highly variable scenarios encountered, and even more so in developing countries. Jechoutek and Lamech [Jechoutek and Lamech 1995] suggest that greater balance sheet support for subordinated debt and quasi-equity portions of the project financing plans for Independent Power Producers (IPPs) could ease the overall financing costs of projects and could be a transitional strategy for meeting the huge financing needs for IPPs in developing countries.

Some countries have started to address some of these recognised weaknesses of PPPs. In the UK for instance, the use of standard PFI contract documentation (SoPC version 3) is mandatory [HM Treasury 2004]. Under a 2003 Treasury initiative, the UK Government provided 'credit guarantee finance', designed to lower the base cost of senior debt, to the project company on a PPP health scheme [Steadman 2005]. Such interventions are necessary to make PPPs work in developing economies. In the next section of this paper, we present an overview of a DSS framework designed to address the steep learning curve and the lack and/ or loss of asset knowledge by public procuring agents. The DSS framework is being developed as one of the deliverables of an ongoing R & D project that aims to help public procuring agents in Hong Kong target 'value for money' in PPP projects by facilitating knowledge retention and transfer, shortening the learning curve and providing a framework for evaluating and selecting potential PPP schemes. Other issues addressed by the framework will also be outlined.

A DSS FRAMEWORK FOR CONSTRUCTION PPPs

This framework, presented in Figure 1 below, includes a well structured and dynamically developing experiential knowledge base of past cases, good practices, selection criteria and indicators. These primary indicators include sets of Essential Factors (EFs) and Fatal Factors (FFs), in terms of empowering or ‘killing’ PPP approaches respectively. Some examples of EFs are fiscal and budgetary constraints, a stable economic environment, potential for improved services to the community, possibility of sound project cashflows, adequate legal and regulatory frameworks and governmental support [Curnow *et al.* 2005, Duffield 2005, Harris 2003, Li *et al.* 2005]. While the absence of any one EF can be fatal to the PPP prospects of an upcoming project, direct FFs will include political uncertainty, lack of a credible PPP market, concerns over transaction and bidding costs and the inability to clearly articulate what constitutes a successful PPP [Curnow *et al.* 2005, Harris 2003, Robinson *et al.* 2004].

This primary level assessment helps to screen out projects that fail to meet the essential requirements or will be subject to devastating consequences if carried though as PPPs. For example, if FFs are recognised upfront, PPP prospects can be discarded and alternatives sought as at the top right of Figure 1.

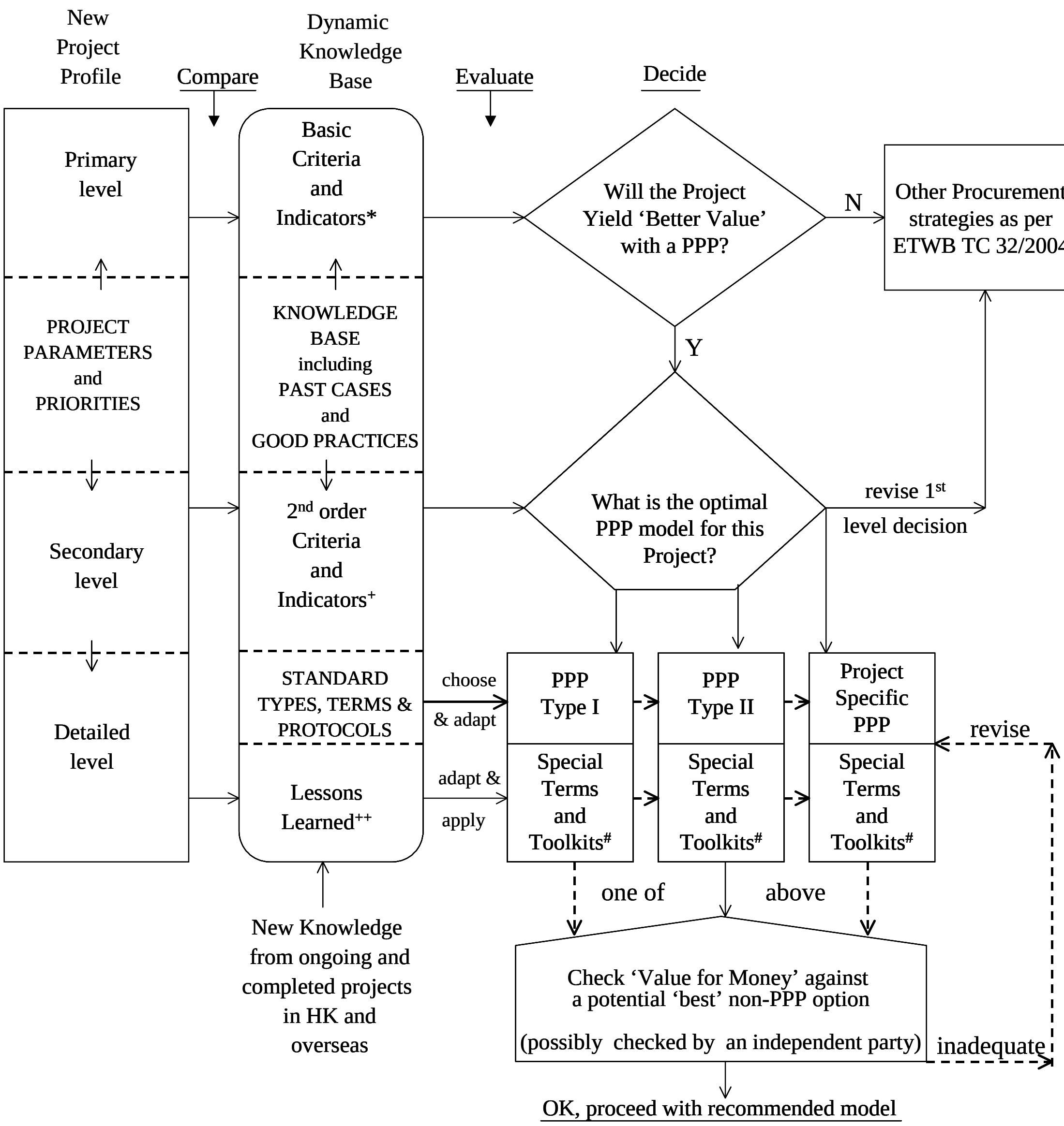

Fig. 1 FRAMEWORK OF PROPOSED DECISION SUPPORT SYSTEM

*	includes Essential Factors (EFs) and Fatal Factors (FFs)
+	includes Common Drivers (CDs) and Common Barriers (CBs)
++	includes Value Enhancers (VEs) and Value Inhibitors (VIs)
#	e.g. guidelines, checklists etc. incorporating CDs and VEs; and counter measures against CBs and VIs (e.g. in guarantees, comfort letters, and/or adjustment mechanisms)

For schemes meriting further consideration, sets of Common Drivers (CDs), Common Barriers (CBs), Value Enhancers (VEs) and Value Inhibitors (VIs), in terms of encouraging or hindering PPP approaches, and in boosting or diminishing the achievable overall value for money, establish the secondary criteria for assessment (see Figure 1). Strong political leadership, commitment by the public sector to seek value for money, the potential for a diversified workload and good returns for private participants and the potential for off-balance sheet funding, have been identified as essential drivers for PPP schemes [Duffield 2005, Robinson *et al.* 2004]. Clearly, the distinction between FFs and CBs is a matter of the severity of impact. FFs can be taken to be insurmountable while CBs are conceptualised here as lower-impact barriers that do not preclude the use of PPP schemes, but hinder their uptake. CBs include such factors as, the difficulty of achieving a proper allocation of risks or of demonstrating value for money and the lack of a track record (i.e. the catch-22 paradox) [Akintoye *et al.* 2005, Curnow *et al.* 2005, Duffield 2005, Robinson *et al.* 2004].

VEs and VIs form the opposite sides of the same coin. VEs include a good independent regulatory oversight of PPP schemes, flexible agreements with built-in adjustment mechanisms that also facilitate innovation, stakeholder support and 'buy-in', the use of relational contracting approaches, government guarantees, accurate determination of the performance-adjusted service fee, a good private consortium, and the ability to capture and transfer knowledge acquired from previous schemes [Boswell 2005, Grimsey and Lewis 2004, Kumaraswamy *et al.* 2005, Li *et al.* 2005, Robinson *et al.* 2004, Steadman 2005]. Inaccuracies in the assessment of the funding requirements or in defining the measurable level of service demanded, inadequacies in the briefing documents or client requirements and the inability to sustain competition, are thought to greatly inhibit the scope of value for money achievable on PPP schemes [Robinson *et al.* 2004, Tiffin and Hall 1998].

It is proposed to build up a library of standard PPP types with groupings of type-specific terms and conditions, protocols and lessons learned. The project profile of an upcoming project can be modelled, using standard templates provided, and compared against similar scenarios captured in the knowledge base, as in the left part of Figure 1, before proceeding to evaluate its PPP prospects. Standard toolkits will be developed; and based on the identified PPP type and project profile, these toolkits will suggest a set of incentivised CDs and VEs and a parallel set of countermeasures against CBs and VIs. These two sets of factors will: (a) assist with the assessment of a potential scheme for suitability under each of the standard PPP types; and also (b) help draw on lessons learned in addressing the challenges and improving VfM. Figure 1 indicates how the first level evaluation leads to a hierarchy of decisions, starting with a VfM check. If suitable for PPPs, the next stage guides a decision on the optimal type of PPP, with each decision stage drawing on relevant 'knowledge' from the dynamic knowledge base. The final PPP type chosen will be an adaptation of an existing type, or an entirely different project-specific type as shown in Figure 1. The final VfM check could lead to further fine-tuning.

CONCLUSION

PPPs can be very useful in the delivery of public services. It has taken the developed economies close to a decade to gain confidence in the wider application of PPPs across different sectors. Rather than re-invent the wheel of historical failures, developing economies need to leapfrog the barriers to successful implementation of PPP arrangements. This requires consolidating the widely dispersed and inadequately documented knowledge on PPPs in various countries into a codified knowledge base of good practices and lessons-learned to assist public sector decision-making. An overview of such a framework has been presented. The use of this and similar frameworks will facilitate evaluation of, and optimal decision-making on, PPP projects and in real time (instead of in hindsight 'after the event') and so increase the likelihood of achieving value for money.

It is planned to next develop basic database structures and case examples of the 'project profile' and 'past cases and good practices' modules and then populate them with sample sets of the factors proposed above, i.e. EFs, FFs, CDs, CBs, VEs and VIs. A pilot model of the DSS will then be developed in order to demonstrate its envisaged functions and value to potential PPP initiators.

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Using Non-financial Public Private Partnerships for the Maintenance of Infrastructure Facilities

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Abstract
The maintenance of infrastructure facilities is an arduous and costly task as not only do the facilities spread over an extensive geographical area but the works could also be very diverse and fragmented. While it is the responsibility of relevant authorities to keep up with the status of the facilities, the financial burden and workload of the government in maintaining them are extremely high. Some public authorities are now bringing in novel ideas such as non-financial Public-Private Partnerships (PPP) to infrastructure maintenance. Using non-financial PPP, the service provider is reimbursed according to the level of attainment to a predetermined performance/output specification. In Hong Kong, several infrastructure maintenance projects are awarded through this type of arrangement, and it is interesting to find out the potentials and pitfalls of extending non-financial PPP to other similar infrastructure maintenance schemes. In this paper, the features of non-financial PPP are introduced. The implementation of non-financial PPP for infrastructure maintenance projects is examined through a survey conducted in Hong Kong. The results show that the public authorities and service providers generally believed that the mechanism for reimbursing the services provided would work and support the use of this type of arrangement for the maintenance of infrastructure facilities.

Keywords
Public-private partnerships, maintenance, infrastructure facilities, government.

INTRODUCTION

There is a growing trend for governments worldwide to explore new infrastructure procurement routes such as various forms of Public-Private Partnerships (PPP) due to restricted fiscal budgets and an increasing demand for infrastructure facilities (Zhang *et al*., 2002). In the absence of a universally acceptable definition of PPP, the key components to be provided or delivered by the private partner in a PPP scheme is usually the physical facility itself and its subsequent maintenance and operation (Zhang and Kumaraswamy, 2001a). In return, the franchisees recover their capital investment via the terms set out in the concession agreement viz. the concession period, a proposed tariff regime and a desired investment return (Ngee *et al*, 1997).

The idea of PPP is not new to Hong Kong. Since the late 1960s, Hong Kong has gained valuable experiences from the successful development of five large-scale tunnel projects using the Build-Own-Transfer (BOT) approach (Zhang and Kumaraswamy, 2001a). It is believed that PPP can harness flexibility, encourage innovation, enhance productivity, allow better risk allocation, increase value-for-money and improve cost-effectiveness by involving the private sector in the provision of public services (Akintoye *et al*., 2003).

In the Policy Address 2003, the Chief Executive of the HKSAR Government had set out 'big market, small government' as the underlying principle of governance, aiming at increasing investment and employment opportunities in the community while controlling the size of the civil service (Efficiency Unit, 2003). In response to that, the government of HKSAR has begun to explore various options of private sector participation.

Aligning with the government direction, a Works Department of the HKSAR Government has piloted the concept of PPP on the maintenance of infrastructure facilities [hereafter referred as the Projects] in 2004. Being different from Private Finance Initiatives (PFI) – the most common form of PPP (Grimsey and Lewis, 2002), these Projects involve no financial investment from the service providers. Instead, the public authorities would reimburse the performance of the contractors.

Since the idea of applying non-financial PPP to maintaining infrastructure facilities is rather novel, it is worth examining the effectiveness of this type of arrangement, especially the payment reimbursement mechanism. The paper begins by highlighting the characteristics of non-financial PPP. The research methodology is then introduced, and the successfulness of implementing non-financial PPP for infrastructure maintenance projects is elucidated. The paper concludes by the recommendations for future improvement.

CHARACTERISTICS OF THE PROJECTS

The Projects have taken the form of a maintenance and management contract and are performance-based in nature. Under such arrangement, the service providers are responsible for providing scheduled maintenance services including inspection, planning, design and supervision for repair and minor improvements of the facilities, as well as for handling complaints from the public during the contract period. However, in the Projects being examined, only certain proportion of routine maintenance works are covered by PPP. The rest of the non-scheduled, unplanned works are carried out according to the traditional work orders system.

Unlike in a traditional term contract, the contractors of the non-financial PPP maintenance projects receive a fixed amount of payment for works under the scope of PPP. Payment to the contractors is on a monthly basis subject to the performance of the contractor in different areas of maintenance work. Monthly audits would be carried out by client's supervisory staff to assess the performance standard of the contractor and the monthly sum due to the contractor would then be determined according to the amount of defects found in the audit as specified in the contract.

The performance standard of the contractor is measured by a set of benchmarks in different areas of works as specified in the contract (*cf:* the Portsmouth Road Maintenance Project in UK which is a PFI project). It is believed that the performance-based payment system can allow greater flexibility, encourage innovation, enhance efficiency and improve cost-effectiveness of work by allowing concurrent engineering of functions, use of new materials and techniques (Zhang and Kumaraswamy, 2001b).

The performance-based system in PPP projects not only can allow more innovation (Earl and Regan, 2003; Smith, 1999; Chege and Rwelamila, 2001), but it also helps the government to ensure quality works by transferring the risks to the private sector partner through the use of a performance specification instead of a traditional specification (Johnston, 2004). Provided the outputs are clearly specified at the outset and both parties understand the risks they are taking on, PPP can offer better services, deliver services more efficiently and provide better value-for-money (HM Treasury, 2000).

RESEARCH METHODOLOGY

In order to collect the opinions from the management level and front-line staff of the public agents as well as the service providers, semi-structured interviews were carried out to capture their perceptions and to explore their understanding of this new issue. An interview protocol was developed for this study exercise. The questions strive to examine the successfulness of the payment mechanism of the Projects. The interview protocol was dispatched to the interviewees in advance to expedite the interviewing process. Face-to-face interviews were conducted subsequently.

In this study, a total of 16 personnel were interviewed. 12 out of the 16 interviewees were from the Works Department, and the others from the contractor. They included senior staff at management level, project staff working for PPP and traditional term contract, and also staff who had been involved in the contract administration of the contracts. The other 4 interviewees from the contractor side were of management level in the PPP contract and a consultant's representative who was working for the contractor. The profile of the interviewees is highlighted in Table 1.

Table 1. Profile of Interviewees

Organization	Type	Interviewee
Government	PPP	P1, P2, P3, P4, P5, P6
Government	Term	H1, H2, H3, H4, H5, H6
Contractor	PPP	C1, C2, C3, C4

SUCCESSFULNESS OF CURRENT IMPLEMENTATION

Performance-based Payment System

Interviewees H1, H2, H3, H5, H6, P4 & P5 agreed that the performance-based payment system is effective as it helps saving resources for supervision and measurement work. They thought that this can reduce the interfaces between the government staff and the contractor and thus minimizing the chance of corruption. Besides, more flexible method of work is allowed to be carried out. The overall performance can be improved by tying payment to performance. However, as suggested by Interviewee H3, it may be difficult to define the performance standards and the amount of disputes would increase if the standard set is too difficult to achieve. Interviewees P1, P2 & P6 did not agree with the effectiveness of the performance-based system. They thought that not all work can be check on a performance basis, e.g. hidden works. Supervision is required so as to ensure that the contractor has really carried out the work.

The four interviewees from the contractor group also agreed that the performance-based system is good and effective as it can ensure that the government can get what she wants. For example, instead of specifying on the number of operations to be carried out by the contractor per day, by defining the requirement of the facility condition, the government can ensure the desired performance level is maintained. Interviewee C4 argued that some performance standards are difficult to be achieved with reasonable resources. In such cases, the client representative should also consider the contractor's input and effort.

Regarding the achievability of the performance standard, the results obtained are very diverse. Interviewees H3, H4, H6, P1& P3 believed that the standards set are fair and achievable although a learning period may be required by the contractor. Interviewees P2 & P4 thought that the achievability of the standard depends on the resources input and the contractor's expertise. Interviewees H2, H5, P5 & P6 thought that some of the performance standards are difficult to be achieved. It may require too much resource from the contractor and thus is unrealistic.

Interviewee C3 from the contractor believed that the standards can be achieved depending on the resources input. However, other interviewees (Interviewees C1, C2 & C4) thought that some performance standards are difficult to be achieved with a reasonable amount of resources.

Most interviewees were satisfied with the appeal mechanism as it can provide a safety net for the contractor. However, Interviewee C4 claimed that it is unreasonable to require the contractor to provide evidence for appeal which is a waste of effort and resources from the contractor. Interviewee H1 suggested that the contractor should have a complete quality control system and a recording system for their work where information can be easily retrieved.

Payment Deduction Mechanism

All interviewees from the government thought that the payment reduction mechanism is effective in improving the performance of the contractor. It helps to point out the problems areas of the contractor and the contractor can then take corresponding measures to improve. Interviewee P2 thought that the actual effectiveness greatly depends on the amount of payment reduction.

Interviewees C1, C2 & C4 from the contractor thought that the payment reduction system is not very effective and cannot give a strong motivation for them to improve. They think that it is their responsibility to do the work, but this should not be driven by payment reduction. A reward system (e.g. bonus or cost-plus) was preferred. Interviewee C3 thought that the system is effective as the contractor can know about the problem and where the black spot is from the amount of default notices received. However, Interviewee C4 pointed out that the contractor may only carry out work in the spotted areas in order to avoid receiving a default notice.

Audit System

Most interviewees from the government (Interviewees H1, H2, H3, H5, H6, P2, P3, P4 & P6) believed that the monthly audit frequency and resources are enough. As the audits are carried out on a random basis, it can reflect the actual performance of the contractor (all except Interviewees P4

& P5). Interviewee H4 thought that the audit frequency in some areas maybe too high. On the other hand, Interviewees P1 and P5 believed that the audit frequency is not enough. P1 suggested that there should be more audits at the start of a project. For the practicability of the audit system, Interviewees H2, P1, P3, P5 & P6 believed that some of the audit methods are time consuming and are impractical or difficult to be carried out. Interviewees H1 suggested that the amount of audit could be reduced gradually. He believed that if the contractor is good, there is actually no need for auditing. In a long run, there should not be any check on the physical work but the audit system of the contractor. Interviewee P2 thought that some audit checking is based on subjective judgment, and thus is unfair to the contractor.

From the viewpoint of the contractor, the resources to witness the audit are enough. However, Interviewees C3 and C4 thought that the frequency of audit is too high and it takes them a lot of time to 'entertain' the auditor. Interviewee C4 suggested that there should be observation instead of auditing. Audit is only required to be carried out when the condition of the facilities is found unsatisfactory. They thought that the requirements of the client representative are too strict. Interviewees C1, C2 and C4 felt that the system is unfair to them due to the subjective judgment and the performance standards being too high to be achieved with reasonable resources.

Problems Encountered

As PPP is a newly introduced concept in maintenance projects, the form of contract, specification and method of work, etc. are all new to both the client and the contractor. Thus it is expected that there would be many difficulties experienced by the two parties during the implementation of the PPP contract. The problems encountered by the interviewees include:

- Different interpretation of the standards leading to disputes. There are also arguments on the definition of defects. More time is needed for both the contractor and the government staff to adapt to the new system (Interviewees H1, H2, H6, P1, P2, P3, P4, P6, C2 & C4).
- As there is no longer full-time supervision, it is difficult to check if the contractor has really carried out the work (Interviewee P2).
- There are a lot of submissions from the contractor and it is time consuming for the government staff to do the recording work (Interviewee P3).
- There is not enough time for the contractor to prepare as there were only a few weeks after the award of contract for the contractor to carry out planning, programming and setting up. Besides, not enough information was given at an early stage of the project due to poor inventory (Interviewee C1).
- It is difficult to adapt to the change from the normal practice to the perfect maintenance standard required (Interviewee C3).
- The contractor is not doing well in the submission of progress report and updating of work programs. Many conflicts arise due to poor communication (Interviewee H5).

SUGGESTED IMPROVEMENTS

Audit System

- A longer learning period should be allowed for fine-tuning (Interviewee C1).

- A more scientific method should be developed to check the degree of confidence in determining the performance of the contractor by the random sampling audit system (Interviewees H5 & H6).
- Instead of monthly audits, assessment can be carried out over a longer period (Interviewee C4).
- Communication between the auditor and the contractor should be improved to find out the reasons for the problems instead of merely pinpointing errors (Interviewee C3).
- In the long run, there should be no physical auditing but only quality system control auditing (Interviewee H1).

Performance-based Payment System

- The top management level of the contractor should educate their staff on the importance of keeping up the quality of maintenance work (Interviewee P4).
- The relationship between the defect rate and payment should be made more reasonable. A more scientific method can be developed to link the amount of defects found in the audits with the payment entitlements (Interviewees H5 & P6)
- The contractor can also be invited to witness the defects on issuance of default notices. This can help the contractor to understand more about the condition and to allow immediate clarification, thus reducing conflicts between the two parties (Interviewee C3).
- The assessment for payment should also take into consideration the contractor's effort and resources input (Interviewee C4).

Overall Implementation

- Top level management of the contractor should educate their staff so as to inculcate them with the new culture and the spirit of partnering (Interviewee H1).
- A longer gearing up period should be allowed for both parties to adapt to the new system and understand the new requirement (Interviewees H2, C3 & C4).
- A longer tender period should be provided for the contractors to check the initial condition of the facilities. Besides, more time should be allowed for the contractor to carry out planning and programming before the start of the project (Interviewees C1 & C2).
- The public sector client should ensure that the facilities are in good condition before giving it to the contractor. The requirements should be more reasonable, and they should not require the output quality to be much better than the initial condition given (Interviewees C1 & C2).
- Audit checking should be carried out strictly at the beginning of the project so as to push the contractors to improve (Interviewee H5).

DISCUSSIONS

Most interviewees (except P4, C1 & C3) agreed that PPP can be extended to all maintenance projects gradually. They believed that PPP can reduce the workload of staff in the government and help in building a small government. Interviewee H9 suggested that PPP can be tried on different projects to evaluate the effectiveness before extending to other projects. Interviewees H1, H2, H4, P1, P4, C1, C2 & C4 agreed that PPP can also be extended to other infrastructure facilities. Yet, the implementation would be more difficult as there are more work items and involves many different parties.

It is expected that there will be a change in the roles of the existing project staff for both the government and the PPP contractors should non-financial PPP be more extensive used for maintaining infrastructure facilities. Interviewees H4, P1, P2 & P6 pointed out that the major work of inspectors and work supervisors has been changed from inspection to audit and from issuance of work orders to preparation of default notice, as well as inspection and audit reports. Their nature of work has been changed from technical to clerical. Interviewee P6 thought that the number of inspectors and work supervisors could be reduced by 10 to 20%. Interviewee P1 opined that PPP can help relieve the problem of resource shortage. For the role of the engineers, Interviewees H1, H4, P1, P2, P6 thought that there would be little change in the role of engineers but the amount of administrative work may increase.

On the side of the contractor, Interviewees C3 & C4 thought that there would be additional staff for the contractor as they have taken up the inspection work. Communication between the inspectors and site agents would be more efficient as they are at the same level. Interviewee C1 opined that there would be less planning work than before as the programming work is front-ended, but there would be more reporting work for the staff. Interviewee C2 suggested that work supervisor and ganger can be combined under the PPP approach.

CONCLUSION

The findings of the interview show that maintaining infrastructure facilities through non-financial PPP is feasible provided an equitable performance standard can be drawn up. Despite that, owing to the conflicting interests between the joint partners, special attention should be taken to prevent possible pitfalls. Problems may arise in a PPP project due to the differences in interests and corporate culture between the public and private parties. The pursuit of social benefits by the public sector does not naturally go together with the pursuit of commercial benefits by the private sector. Adequate preparation is the critical success factor for a PPP project as it was found that most problems arising during the implementation of a project often originate from the preparatory phase (Reijniers, 1994).

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Risk Mitigation for the Private Power Projects Investors in Brazil – The Guarantees Structure.

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Abstract
This paper deals with the mechanisms of risks mitigation designed for non-expert private investors in Private Power Projects in Brazil, taken into account the specials features of the Brazilian electricity market and economic behavior of the country as well. It is assumed in this article that all projects will have their funding by limited-recourse systems.
Firstly, the sector scenario will be briefly exposed specially in what concerns to the current generation model and to the demand for energy, based on the new Brazilian electric model disposals. Secondly, we present the main risks related to a typical power project in Brazil and its funding structure as well.
Finally, by using a prototype of a power project, we describe the special purpose environment within occurs the project development, pointing out the hole of each stakeholder involved in the Project Finance and the mechanisms for risk mitigation for the private investor.

Keywords
Project finance, mitigation, private power projects, risk analysis, guarantees.

THE BRAZILIAN ELECTRIC MODEL AND THE DEMAND FOR NEW INVESTMENTS IN POWER PROJECTS

The Brazilian generating energy system has a current capacity of 91,704MW. It is divided into small isolated systems ones and the National Linked System (SIN – Sistema Interligado Nacional). The SIN is composed by four sub-systems – North Linked System, Northeast Linked System, Southeast/Mid-West Linked System and South Linked System, they altogether generating 97% of the total national capacity. The Brazilian generating system is characterized by an expressive predominance of hydroelectric generation. The share of such kind of generation reaches over 75% of the total capacity in Brazil. Another important feature of the system is the long distances from the generating facilities to the consuming centers and, therefore, the system requires an extent net of integrated transmission lines.

Since the Brazil 2001 energy crisis, there has been an orientation towards changes in the energy matrix, searching to reduce the system exposition to hydrological risks through incentives to increment investments in thermal plants and exploitation of alternative energy sources. According to the National Agency of Electric Energy (ANEEL – Agência Nacional de Energia Elétrica), until June, 2005, the Brazilian energy matrix, was composed of 76.3% of hydroelectric energy, 21.4% of thermoelectric energy and 2.2% of thermonuclear energy, being the remaining part provided by alternative power sources.

According to the Brazilian Mines and Energy Department (2003) (MME – Ministério de Minas e Energia), nowadays, there is an excessive energy supply, capable to support the demand until mid-2006, although the country needs to extend its generating capacity in nearly 3,200MW per year to sustain an annual growth projection of 4.5% in the Gross Domestic Product (PIB – Produto Interno Bruto) up to 2010. However, according to the forecasting made by the MME, the country needs around US$ 5.7 billion annual investments in the electric sector, which ones should be derived in 50% to generation functions, 34% to distribution and 16% to transmission. These requirements are essential to prevent low energy supply between 2007 and 2009. Otherwise it could abort economical growth perspectives for such years.

In order to adjust the energy supply increase, in March 2004, the Brazilian government approved the laws 10.487 and 10.848. These laws established the guidelines for the new Brazilian electric market. According to the MME, this new model has the following main objectives: to ensure the efficiency of operation and service provided to consumers; to assure reasonable fees; to create a steadily regulatory environment to stimulate the competition and new private investments; keeping strong orientation not only to the long term planning, but also medium and short ones.

The institutional structure of the Brazilian new electric model is focused on planning, supply security, regulation and selling and buying transactions control. The new structure comprehends, with no hierarchy whatsoever, the following entities:

- **National Energetic Policy Board** (CNPE – Conselho Nacional de Política Energética): multi-ministerial and technical counseling agency for the Republic Presidency. It is headed by the Mines and Energy Minister. Its objectives are: to formulate national policies focused on the rational exploitation of the country energy resources; to review periodically the energy matrix and to manage specific sector programs.
- **Mines and Energy Department** (MME – Ministério de Minas e Energia): the department's role is to originate and to execute in the federal level the national energy policy.
- **Energy Research Company** (EPE – Empresa de Pesquisa Energética): federal public company bounded to the MME. Its functions are related to studies of national energy planning, amongst others, the composition of the national energy matrix projections, the national energy balance, the maximum use of water resources, the environmental licensing and, finally, the planning expansion of generation and transmission of electric energy in long, medium and short terms.
- **Electrical Sector Monitoring Committee** (CMSE – Comitê de Monitoramento do Setor Elétrico): group coordinated by MME whose purpose is assure continuity and security to energy supply.
- **National Agency of Electric Energy** (ANEEL – Agência Nacional de Energia Elétrica): it is an autarchy bounded to the MME, whose purpose is to control and regulate generation, transmission, trading and distribution of electric energy across the domestic territory.
- **Electrical System National Operator** (ONS – Operador Nacional do Sistema Elétrico): it is a private entity, but with no profitable purpose, under regulation and supervision from ANEEL. The ONS aims to control functions of generation and transmission in the National Linked System.

- **Electric Energy Trading Chamber** (CCEE – Câmara de Comercialização de Energia Elétrica): it is a private entity, but with no profitable purpose, under regulation and supervision from ANEEL. The CCEE manages the electric energy trading process.

At a first sight, the intervention of the government in the sector strategic decisions is contrary to the main objective of the new model first goals, the attractiveness of private investments. The strategic planning for the electric sector, as pointed out in the new model institutional mission, lays down on the sole responsibility of MME, besides the EPE has a decisive role in giving concessions to new projects. However, regarding specifically to the sector planning, the complexity and size of Brazil's national electric system, its great dependence on hydraulic sources, and, moreover, the co-dependence amongst the four great regional systems and the excessive number of operating agents, is essential to have an integrated and impartial sector regulation, conducted by a private entity, to ensure adequate operation and expansion of the energy offering in the Brazilian market.

Taken into consideration the factors referred to the private investments attractiveness, which constitutes the scope of this article, it's worth to describe how electric energy trade will be occur. The Generation companies will trade produced energy in two distinct markets, as follows: Regulated Contract Environment (ACR – Ambiente de Contratação Regulada) and Free Contract Environment (ACL – Ambiente de Contratação Livre). In the ACR, the energy to attend regular consumers will be contracted upon a pool of distributing companies by regulated contracts, in order to promote reasonable fees to the final consumer. In the ACL, the generating companies will be free to negotiate contracts. They will trade energy with consumers called "free". These consumers are those with charge demands equal or above 3,000kW, in any voltage band.

The bidding process for new generating projects will always happen with little advance towards purchasing and selling energy auctions in the regulated environment. Power purchase agreements among generators and distributors must be signed in a first bidding five years before the distributors demand requirements. In a second moment, after two years past the first event, in a second bidding, which has no effect in deals closed in the first event, the contracts are made straightly to new plants having just a three-year to start up generation. The purpose of such scheme is to allow distributors to adjust energy demand perspectives set in the first bidding. The bidding processes of purchasing new energy, in the first and second event, must obey the following stages:

1. The ANEEL confirms along with consumers the foreseen demand established by distributors and suggests a list of projects that having previously approved environmental licenses. This list follows an increasing scale of economical merit to attend consumption expansion projections. The Global amount of energy assured in the projects list must substantially exceed demand foreseen.
2. The bidders show price proposal for assured energy to the listed plants or alternative ones. The energy price can be defined by observing available power purchase agreements, in which bidders propose prices to available energy. In such way, the demand risk is transferred to the distributor, otherwise, it can be handle by an energy quantity contract. In this case, the bidder proposes prices considering that the provided energy must be the same as in the assured energy certificate issued by ANEEL. Therefore, the exceeding of energy with no purchase warrants is a risk that must be assumed by the generator. The fees, in the first case, should be inferior to the second due to the different risk exposition degrees in both situations. The Bidders must specify in their bid, the assured energy amount available for own consumption, for trading in ACR and ACL.
3. ANEEL set up the lower fee bid to each plant in the list.

4. ANEEL commands plants bids in increasing order of energy fee.
5. The ANEEL selects plants by energy assured amount, until the bid demand volume is reached. It must be observed despite of the lower fee criteria, a minimum pre-defined participation in thermoelectric plants attendance.
6. The MME grants exploitation rights and common property use, for up to 35 years, to winners in electric generation bidding.
7. The generators sign bilateral power purchase agreement, which will last from 15 to 35 years, with supply beginning 3 or 5 years after contract signature, as they are firmed up in the first or second bidding. The Contracts types vary from energy amount or available ones and must be firmed up with each distributor in the pool. The Guarantees to generator will be, essentially and in this order, the receivables from distributors and financial assets owned by distributors.
8. During the generation plants operation cycle, there will be *ex post* re-arrangement instruments regarding to adjust the total energy amount generated in the system, to eliminate, or at least, to balance differences between energy amount really generated and those assured in each generating system plant, seeking thus prioritizing bilateral contracts fulfillment. In energy amount contracts, responsibility for eliminating and balancing transactions management rests with generating companies, but in available energy contracts, responsibility belongs to distributors themselves.

The Generators can be classified in Public Services Concessionaires (CSPG – Concessionários de Serviços Públicos de Geração), Electric Energy Independent Producers (PIE – Produtores Independentes de Energia Elétrica) and self-producers. Both CSPG and PIE are able to trade energy with (I) distributors in the pool, using ACR, by bidding, through CCEE; (II) individual buyers, also by public bidding, through CCEE, in order to set up ordinary adjust contracts; (III) free consumers, directly or via traders and (IV) as exporters, previously authorized by grantor and registered in CCEE.

The Brazilian new electric model has been in force since March 2004. Since this date, there have not been occurred any auction involving concessions granting for new electric generation projects. The first auction for new energy purchasing will occur in 2005 December 16th, for what ANEEL have bidden a list of 17 generation projects for concessions, as presented in the table 1. As there are no concessions for generation projects granted after the new legislation approval, which would permit us analyze, through observation, the new model capacity for attracting new private investments for the sector, in the next sections, we discuss the new model’s risks and the ones commonly associated to power generation projects, seeking value the new regulatory structure capacity to ensure the financial recourses flow to support the expected growth of energy demand in the country.

Table - 1 List of Hydroelectric Power Plants to be granted in December 2005

#	Name	State	Power (MW)	#	Name	State	Power (MW)
1	Baguari	Minas Gerais	140	10	Ipueiras	Tocantins	480
2	Itaguaçu	Goiás	130	11	Mauá	Paraná	382,2
3	Salto Grande	Paraná	53,3	12	Mirador	Goiás	80
4	Simplício	Minas Gerais / Rio de Janeiro	324,8	13	Paulistas	Goiás / Minas Gerais	52,5
5	Baixo Iguaçu	Paraná	350	14	Retiro Baixo	Minas Gerais	82
6	Barra do Pomba	Rio de Janeiro	80	15	Telêmaco Borba	Paraná	120
7	Cambuci	Rio de Janeiro	50	16	Passo São João	Rio Grande do Sul	81
8	Dardanelos	Mato Grosso	261	17	São José	Rio Grande do Sul	45
9	Foz do Rio Claro	Goiás	67				

HYDROELETRIC POWER GENERATION PROJECTS

Characteristic Risks

Hydroelectric generation projects, as well as other projects that involve common property exploitation, embraces two different and well defined stages with characteristics and risks of their own.

The first one constitutes the implementation stage, which lasts from 3 to 5 years, period of intensive capital investment. Financially, this stage is characterized by a concentrated investment flow and an absence of income generation. In a management perspective, the main tasks are related to Engineering, Procurement and Construction (EPC) contract. In this phase, project risks are associated to environmental issues, to long term financing contracts delay and, depending on the nature of the EPC contract, to deviation in implementation costs and delay in operation beginning due to performance go down in construction management, unpredicted events and macro-economic or sector scenario breakdown.

Except for macro-economic and unpredicted risks, the risk mitigation during implementation cycle is essentially attached to the EPC suppliers' contract disposals. Risks in increasing construction costs or delays could be shared in contract, between developers and suppliers, according to each agent's risk management capacity. The EPC suppliers are able to assume risks from delays and cost increase related to efficiency failure in their processes, as long as developers assume total or partly risks regarding unpredicted events, or macro-economical scenario deviation, for which suppliers cannot deal with (FINNERTY, 1996). Bonomi and Malvessi (2002) verified that it's a common practice in Brazil that the hydroelectric generation projects EPC contracts are based on turn key terms. In such cases the EPC suppliers assume full responsibility in delivering the plant ready and operative to the generator, on a previously arranged date, and for a pre-arranged fixed price as well. The EPC suppliers offer guarantees of arranged conditions fulfillment, such as performance and accomplishment insurance.

On the other hand, the developer must take those Risks associated to social and environmental factors, along competent institutions and under EPE supervision, which among other attributions, is responsible for bid projects environmental feasibility.

The second stage comprehends the project's operation phase. In this stage the risks are not only linked to higher operational, maintenance and preservation costs, but also and mainly to risk of the market. In other words, the project performance get worse as a whole when energy amounts are traded in inferior quantity or at lower prices than those defined during planning phase (ALENCAR, 1998).

Operational inefficiency risk must be taken by developer or shared, as mentioned in the construction phase discussion, between developer and a third party contracted out to operate and maintain services. From a passive investor point of view, the developer or this third party must assure the achievement of demand levels in pre-arranged quantity and quality patterns through performance guarantees.

The demand risks, at least in ACR, are partly mitigated by both, the structure of the new project concession bidding process and the rules for energy trading in the market. As previously mentioned, ANNEL grants exploitation rights to generators, by proposed price order, until it get assured energy from granted plants that equalizes contract demand level estimated by the energy distributors pool. This pool has pre-contracted 100% of their energy demand through agreements firmed up 3 or 5 years before the demand to arise, and they have duration from 15 to 35 years, regulated by CCEE. Therefore, in ACR, the economic wealth of new projects concessions is directly dependent on pre-existing purchase agreements.

In these cases, risks during operational period are summarized into (i) gaps between operational costs and energy prices inflation rate; (ii) energy generation not formally assured in contract. Risk factor present in contracts like energy quantity, but subjects to mitigation, if it were signed with available energy clauses, where this risk is transferred to distributors; (iii) distributors insolvency, nevertheless is a partially pulverized risk, once in the new model are firmed up bilateral contracts between generators and each pool distributors member. In addition, the new rules establish adjusting mechanisms between pool members when payment obligations are not fulfilled by one of them. Outside ACR, the generators are truly exposed to all market risks, regarding to the energy lot they choose to trade in ACL or in exportation market.

The Funding and Principal Actors

Hydroelectric generation projects are usually developed in a Special Purpose Company – SPC. The SPC isolates the project and protects it from developers' business portfolio risks. In Brazil, taken into account the intensive investment requirements and relative protection of the income flow during operational phase, hydroelectric generation projects have a typical capital structure composed of: (i) a small part of developer's equity, who holds SPC stock control; (ii) pulverized investors, essentially institutional entities – large investment funds, pension funds and insurance companies – who acquire SPC's debt bonds, as well as (iii) long term finance institutions, such as development banks – in Brazil, with remarkable action in electric sector projects, we have the National Bank for Economic and Social Development (BNDES – Banco Nacional de Desenvolvimento Econômico e Social) – multilateral and bilateral credit agencies, Export Credit Agencies – ECA and private banks (ALENCAR, 1998).

The long term financing agencies usually offer credit to developers in favorable conditions. The BNDES, i.e., offers credit lines specifically for enterprises financing (FINEM – Financiamento de Empreendimentos) and directed to machinery and equipment acquirement (FINAME -

Financiamento de Máquinas e Equipamentos), with favorable indexed interest rates for Brazilian companies, called long term interest rate (TJLP – Taxa de Juros de Longo Prazo), plus a basic spread of 2,5% and a risk spread also about 2,5% a year. In general these debts have an amortization span of approximately 10 years, and a grace period up to 6 months after the project completion. The banks usually demand as protection for funds made available, guarantees from borrowers and covenant introduction to assure project financial debt liquidation.

The main structural characteristics of electric generation projects are the intense investment concentration in the beginning of implementation phase and the long term of the return flow, but usually with low fluctuation levels. This profile keep strong similarity to non aggressive investors behavior, who detain large financial capacity, besides, they set up as their investments target those that can be understood as value reserve and with some risk protection, usually associated to relative low return rates, equivalent to conservative investments.

Due to these characteristics, in Brazil almost all of the new power projects are being financed through private bonds offered in the domestic capital markets. These bonds usually are formed with conservative interests, compatible to typical risk configuration of power projects. Besides, the bonds may be conceived in many formats, varying according to the project financial flow, risk protection degree and internal rate of return offered to investors. The power projects bonds usually have part of their interests fixed by developer and, other part carried over from the project operational performance, in such case, they can be protected or not by guarantees structured by the developers. Actually, the more investors profit were linked to the project operational performance, and the more restrict were investor access to the developer assets, the more the project financial structure will be closer to the Project Finance system (BORGES, 1999).

According to Borges (1999), the first Project Finance developed in Brazilian electric sector was the ITÁ Hydroelectric Power Plant with 1450 MW, placed in Uruguay River, in the borders between State of Santa Catarina and Rio Grande do Sul in Brazil's south region. The project funding was composed by a portion of developer's equity of 30% and a debt part of 70%, obtained in a non recourse condition, along with IDB – Interamerican Development Bank and BNDES, whose participation comprehended a parcel of long term loan and another one of bonds issued by the SPC created to allocate the enterprise. Another Project Finance case occurred, in this case in a limited recourse basis, was the implementation of Machadinho Hydroelectric Power Plant, placed in the same Uruguay River, with 1200MW. This project was developed with an equity/debt relation of 35%/65%, being the debt part formed by a long term loan conceded by BNDES and by a bond issuance in the capital market. Debt bonds were remarked with a selling option to BNDES in the end of the 9th concession year and were guaranteed by the project sponsors. The BNDES loan was partly guaranteed by the project sponsors too and in another part by commercial papers issued by the SPC Machadinho.

The Cana Brava Hydroelectric Power Plant, located in Tocantins River was another project structured in a limited recourse basis too. This project had a funding equation composed by 30% of developers equity, 35% of IDB loan and 35% of BNDES recourses, obtained through a debt bond negotiation. The enterprise had the Power Purchase Agreement firmed up since the implementation beginning what contributed to reduce risks and besides, was included in the Hydrological Balance Mechanism, that promote the division of the generated hydroelectric energy between the Brazilian generation companies, reducing the hydrological risks. According to Faria (2003), although the favorable financing conditions, the balanced risks distribution and IDB participation, reducing project's regulatory and political risks, additional developers' guarantees were required for this project becoming the project finance structure a limited recourse one.

A PROJECT PROTOTYPE: LIMITED RECOURSE GUARANTEES STRUCTURE

A prototype of the project tries to embody a typical Brazilian hydroelectric plant, as matter of fact this prototype is very to close the project studied by Faria (2003). It is assumed at the prototype that the project funding is composed by the developer own capital, funds got along with BNDES and resources brought through private debt bonds issued to capital market, according to the details below:

- Developers will bring in about 10% of estimated investment requirements by the project, right away, as SPC's seed capital, giving them property over 100% of voting stocks in SPC.
- BNDES will bring a reasonable amount of resources, corresponding to 50% of investments sum, with *pari passu* disbursement to project's implementation program. Loan investment run for 15 years, with a grace period up to 6 months after the completion, capitalized interests during implementation phase and amortization span of 11.5 years, with quarterly principal payments and debt service. Financing costs will be composed by TJLP, basic spread of 2.5%, plus risk spread of 2.5% too. In addition to this, 0.25% of every disbursement will be destined to BNDES in reference to Guarantee Insurance during the project construction period.
- Non-specialists investors will commit to acquiring SPC's term debt bonds at project's implementation beginning, considering pre-defined quarterly tranches, compatible with projects' disbursements flow. Debt bonds will offer minimum fixed interests, assured by developer, equivalent to inflation indexer of energy trade contract plus 10% annual earning margin over invested values. Besides this, regarding risk spread, it will be derived to non-specialist investors an annual percentage from project's income, enough to rise investors' annual internal return rate to 13%, considering income expectations used in investment analysis reference scenario.

The developer will firm up turn key contract with EPC services suppliers to delivery, for a span and a fixed price, the project ready and operative. The developer must assure to the project creditors – BNDES and non-specialists investors – that construction will be concluded in schedule and any additional funds needed to accomplish it, will be obtained by developer's sole responsibility. The developer also must assure that, in case the project is not operative in scheduled time, or even not concluded, additional funds will be brought by himself, to liquidate project's entire debt. As previously referred, the out-of-time completion of the project onus could be, through EPC agreement, shared between developer and these parts, according to each agent's risk management capacity.

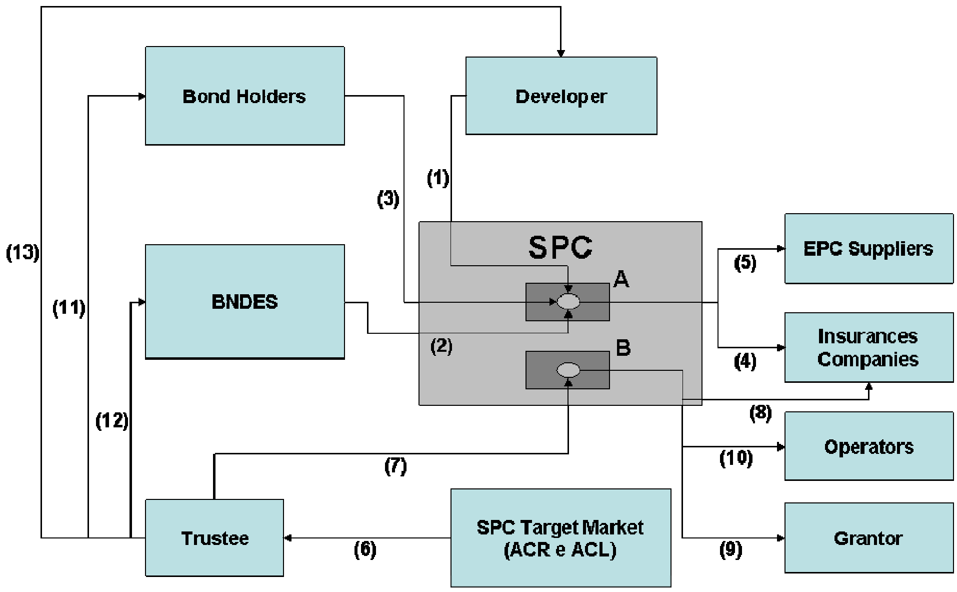
Similarly, during operational period, the developer will sign Operation and Maintenance (O&M) contracts with a third-party specialist. The contract must assure to the creditors that the project operation and maintenance will be performed according to limit quality standards, and any extra funds required to assure minimum agreed quality level will be brought by developer or by the third party responsible for operation, according to risks distribution in O&M contract. The developer also shall, during implementation and operation cycles, contract an insurance policy regarding force majeure events to assure to the creditors the agreed performance.

Market risks, associated to the hypothesis of the price and demand for generated energy going on in lower levels than those estimated, is mitigated due to the fact that the generation and distributors agreement is, at least for energy traded in ACR, *sine qua non* condition to concession granting. These agreements will also offer higher or lower risk to generators as they are based on energy amount or available energy contracts. In the first one, by previously arranged price, generators must assure to the pool of distributor the ANEEL's certified assured energy, and, in the second one, generators will make available to the pool of distributor the generated energy volume, whether it is lower or higher than assured amount. Even though not attached to conceding granting, for energy traded outside ACR, developer may sign future energy trading contracts seen by investors as contained risk or show them that his market projections, in what concerns to the demand and future energy prices, has credibility.

Besides these presented mitigation mechanisms, which are directly linked to the sector's enterprises, it will be detailed others, to reduce SPC's creditors risks, according to the list presented below:

- As guarantee for bonds and BNDES loan, it will be offered 100% of SPC's stocks, including all SPC's property assets, among them, its fixed assets, the emerging water resources exploitation rights and the power purchase agreement firmed up with distributors, traders and free consumers.
- A trustee has the function of controlling the cash flow in SPC, and distributing project's return according to arranged rules. As shown in picture 1, the project's cash flow will be derived to the stakeholders in the following order: (i) to the SPC, solely for maintenance and operation expenses, (ii) for paying principal and interests related to issued bonds, (iii) for the BNDES debt amortization and interests payment and only then (iv) for composing the developer return flow.
- Covenants introduction: (i) maintenance of a minimum capitalization index – *Net equity / Total passive*; (ii) maintenance of a minimum working capital index; (iii) maintenance of a minimum debt coverage index – *Cash flow available for debt payment / Short term net debt*, (iv) restriction regarding shareholders dividend payment and (V) restriction regarding taking new debts without main creditors' approval.

Fig. 1 - Power Project Financing Flows – Characteristics and Hierarchy



FINAL REMARKS

The realization of power projects frequently demands investments of great sums with a long-term return period. This financial tendency in the sector does not match the decreasing investment capacity of public sector in Brazil and in others development countries. As a result, there is already quite a trend in development countries infrastructure sector's a growing participation of the private capital, joined with public investments. For electric energy generation projects, financially self-sustainable and developed under the recent-made regulation disposals in Brazil, which seems to balance the project risks, the Project Finance appears like a valid system for maintain investments in satisfactory levels needed to sustaining Brazil's economic growth goals.

In Brazil, like in other developing countries, where State's investment capacity have been reduced forefront the recourses necessity for the infrastructure maintenance and expansion, and whose economic growth perspectives depend on a continuous increase of the electric energy offer, it becomes priority the creation of mechanisms and a stable environment that assures the access to the private capital and supports a constant resources flow to infrastructure projects. The new Brazilian electrical model has as one of its main objectives, the development of a steady regulatory environment, which besides promoting the competition and assuring efficiency and greater quality in the service installment, encourage the investors to face the hypothesis of anchoring resources to the sector's enterprises.

In emerging economies, the environment's stability and the predictability of the long-term returns flow are drivers of the investor's decision criteria. In this way, the new Brazilian electrical model creates the Regulated Contract Environment – ACR and establishes that each generation company shall firm a long term contract of electric energy supply with each pool's distributor member, for previously agreed price and conditions, which end up mitigating the demand or market risks that, otherwise could inhibit investors and lenders of putting resources up to power generation projects development. The market risk mitigation is a crucial factor to attract the private capital for the sector's projects. However, just this mitigation act is not enough to accomplish private investments, that will only be mobilized if the construction and operation risks are duly treated and distributed among developer and service suppliers and if the enterprise offers a balanced investment x return flows, with an attractive internal rate of return in comparison to other investment option for the private capital.

For the first new electrical energy purchasing auction that shall occur in 2005 December 16th, further the previously listed 17 enterprises bidden by ANEEL which totalize approximately 2.800 MW of installed power, there are already other 115 vendors agents qualified to participate in the auction, whose bidden enterprises totalize more 35.000 MW. The vendors' expectation is the energy price in the first auction round about US$ 50 / MWh and US$ 40 MWh, value enough to produce a medium attractiveness rate of return for investors between 12 and 14% per year.

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Taking Forward Public Procurement Reforms in Ghana

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Abstract

The construction industry in Ghana, like many others worldwide, has had its fair share of damning independent reviews. Huge and unsustainable foreign debt, excessive budget deficits, huge contractual payment arrears, poor construction performance, corruption and pressure from international financial institutions, forced the government to commit to a reform of public procurement, which culminated in the passing of the Public Procurement Act, 2003 (Act 663). The paper outlines the events leading to, and features of, the public procurement reform in Ghana and analyses its potential impact and the unique challenges it presents. Comparisons are also drawn from relevant scenarios in other countries. The paper concludes that while the Procurement Act sets out the legal, institutional and regulatory framework to secure fiscal transparency and public accountability, the sole reliance on traditional contracting and price-based selection limits the scope for the value for money achievable. Expanding the reforms to cover procurement and project delivery methods and strategies, with a focus on 'best value', will increase the potential and likelihood of achieving value for money in public construction in Ghana.

Keywords
Construction performance, Ghana, procurement reform, value for money, VfM

BACKGROUND

A low-income economy in Sub-Saharan Africa, Ghana is a country of firsts. In 1957, it was the first country in Sub-Saharan Africa to emerge from colonialism. It experienced the highest GDP on the continent before an economic crisis in the late 1970s, and was the first survive the trauma of military takeovers. It rebounded after launching one of the first and more stringent economic recovery programmes in the region two decades ago. However, falling prices for gold and cocoa, and rising prices for petroleum imports led to a sharp deterioration in 1999-2000. Through a World Bank-assisted macroeconomic programme, Ghana has made a robust recovery and achieved a fairly stable macroeconomic environment. These reforms also culminated in a new vision of Ghana that emphasizes wealth creation, improved governance and reduced income and regional inequalities. A critical component of this new vision is the government's efforts to promote the private sector as the engine of economic growth. The Government has also identified construction as a priority sector for foreign and private investment.

An approximate annual value of public procurement for goods, works, and consultant services has been given as US$600 million [World Bank 2003] representing about 10% of the country's GDP. The bulk of the expenditure programmes of Ministries, Departments, Agencies (MDAs) and District Assemblies (DAs) involve capital construction procurement [Westring 1997]. Any improvement in the public procurement system will therefore have a direct and substantial impact on the overall economic situation of the country and result in budgetary savings and efficiency in government expenditures. However, successive reviews have revealed substantial inefficiencies and concluded that value for money was not being achieved in both government- and donor-financed procurement. The Public Procurement Act (PPA) (Act 663) was enacted in 2003 to address these weaknesses in public procurement. This paper explores the major issues in construction procurement in Ghana and analyses the potential impact of the Public Procurement Act on the search for VfM in public construction procurement.

INTRODUCTION

All around the world, public infrastructure services needs are fast outpacing the resources for providing them. These socio-economic realities have intensified the search for more innovative means of delivering public services and the need to achieve value for money. However, a persisting spectre of adversarial contracting, sub-optimal outcomes and the deteriorating quality of construction workforce and health and safety performance have threatened to derail efforts aimed at delivering value for money in public construction. Many construction reviews in the developed economies, for example the Latham [1994] report in the UK and the Tang [2001] report in Hong Kong, lamented these developments and made sweeping recommendations for industry reform. Following these, ambitious targets have been set. Some examples include *Accelerating Change* in the UK and *Construction 2020* in Australia. The case histories of construction in these developed economies and their reform efforts and successes have been told and recounted in many forums. The story has largely not been told of the construction industries in low-income countries, whose problems have been further exacerbated by fiscal and monetary constraints and corruption.

Based on a review of literature, this paper outlines the events leading to, and features of, the construction procurement reform in Ghana and analyses its potential impact on VfM and the unique challenges it presents. Comparisons are also drawn from relevant scenarios in other countries. Even though the paper focuses on the construction industry in Ghana, there is considerable evidence to suggest that the case histories enacted here are representative of the situations in many African and some Asian countries [Aniekwu and Okpala 1988, Kumaraswamy 1994, Rwelamila *et al.* 1999]. The issues discussed herein are therefore of broader significance to many developing economies. Considering that the bulk of the global construction market demand is shifting to the developing economies, the issues discussed here will be of significant importance to consultants, contractors and service providers in developed economies that are looking for ways to finance their construction budgets and increase the networth of their companies. The paper starts by outlining the existing framework for public construction procurement. Construction performance is then discussed and comparators are drawn from other countries. The public procurement reform programme is then presented. Notable provisions of the PPA are highlighted and the impact/

significance of the PPA within the broader concept of VfM is analysed. Relevant recommendations are offered for extending the scope and potential for VfM in public construction in Ghana.

FRAMEWORK FOR PUBLIC PROCUREMENT

There is no comprehensive guidance on the scope and procedures of public construction procurement in Ghana. The procurement of construction works and services have been regulated mainly through circulars from the Ministry of Finance, which complement a set of procedures evolved by convention in connection with the control of procurement exercised by the ministry. Central, regional and district tender boards process and award contracts within thresholds defined by the Ministry of Finance. World Bank projects use the World Bank Procurement Guidelines [World Bank 1995] and the World Bank Consultant Guidelines [World Bank 1997]. The procurement method used for public works is the traditional method, with design split from construction. There is a provision for mandatory registration and classification of contractors under guidelines administered by the Ministry of Works and Housing. However, the MDAs and many DAs maintain separate lists for the pre-qualification of contractors and use different standard conditions of contract for works procurement. World Bank-administered projects use the FIDIC conditions of contract for works contracts and shortlists for the selection of consultants.

The classification by the Ministry of Works and Housing has been observed to be too general and obsolete and the registration criteria, lists of contractors and monetary thresholds are not regularly updated [Eyiah and Cook 2003, World Bank 1996]. Except for major or complex assignments, most government-financed architectural consultancy services and project supervision have been assigned to the Architectural and Engineering Services Limited on sole basis [World Bank 1996]. The shortlists used on World Bank-administered projects for the selection of consultants have been observed to be repetitive, with the same firms recurrently selected in civil engineering and building works supervision [World Bank 1996]. Many instances of a single contractor buying and pricing all the bidding documents, and of the award of a number of contracts (or lots) to the same contractor/supplier, under different contracting names have also been observed [Crown Agents 1998, Westring 1997].

CONSTRUCTION PERFORMANCE

The performance of construction in Ghana is poor and many reports have decried the public sector’s lack of commercial edge in the exercise of its procurement function. Contracts for both works and consultancy services take very lengthy periods to reach financial closure and are subject to unnecessary delays [Crown Agents 1998, Westring 1997]. Westring [1997] attributes the causes of the delays to extensive post-award negotiations, delays in the preparation of technical specifications and drawings, delays in evaluation, an extensive system of controls, reviews and approvals, and land ownership disputes. Project implementation has itself been characterised by extensive cost and time overruns and poor quality [Crown Agents 1998, Westring 1997, World Bank 1996, 2003]. The process for payment to contractors and suppliers is also long, involving over thirty steps from invoice to receipt of the payment cheque, and often over-centralized, thus leading to delays in project execution [Eyiah and Cook 2003, Westring 1997, World Bank 2003]. Fiscal constraints and poor procurement practices (as outlined above) have led to insecurity of funding for construction projects and created a constant spectre of delayed payments and payment arrears to contractors and consultants [World Bank 1996]. The accumulated interest on late payments and the frequent price changes due to extensive renegotiations, further exacerbate the funding problem [World Bank 2003].

Consultants and contractors encounter difficulties in processing claims arising from escalation clauses and are indirectly pressured not to push forward these claims [World Bank 1996, 2003]. Many private sector entities delivering works and services to government establishments try to limit their losses by cutting corners or abandoning the work altogether [Westring 1997]. This often has negative consequences for project execution and leads to adversarial relationships developing between contractors and clients. There is reduced respect for contracts entered into with neither party to the contract expecting it to be fully binding. Small contracts and *ad hoc* approaches are favoured at the expense of full-fledged competitive bidding for economic sized projects. Long-term strategic planning by both public and private sectors is difficult and so is the monitoring and control of procurement [Ayirebi 2005, Westring 1997]. Some procuring entities also resort to making contractual payments before the due dates in order to prevent a budget allocation lapse and advance mobilisation funds provided to contractors can exceed considerably the 15% allowable [Westring 1997, World Bank 1996]. Contract management is very poor and so are the training and working conditions of the construction workforce [World Bank 2003].

GHANAIAN CONSTRUCTION - A GLOBAL PERSPECTIVE

This paper focuses on the construction industry in Ghana. Such a focus provides a comprehensive case history of Ghana's procurement reform journey, which makes it easier to model, compare with other construction industries and evaluate the suitability/ applicability of strategies developed in other countries. However, there is considerable evidence to suggest that the case histories enacted here are representative of the situations in many Sub-Saharan African countries in particular [Aniekwu and Okpala 1988, Lopes 1998, Rwelamila *et al.* 1999, Rwelamila and Meyer 1996]. Similar comparators can be drawn in Asia [Kumaraswamy 1994]. The inadequacy of, or deficits in, existing infrastructure services and a rapidly increasing population have left the public sectors in these countries struggling to cope. The infrastructure services required are invariably basic in nature - housing, hospitals, schools, water, and sanitation. These harsh realities have intensified the search for more innovative means of delivering public services and the need to demonstrate value for money in public construction procurement. The issues discussed in this paper are, therefore, of broader significance to the global construction industry.

THE PUBLIC PROCUREMENT REFORM PROGRAMME

The public procurement reform programme is part of a wider reform agenda targeted at improving public financial management. The objectives of the procurement reform proposals are to [Ministry of Finance 2001]: promote national development; enhance harmony with other local and international laws; foster competition, efficiency, transparency and accountability; facilitate ease of procurement administration; and, ensure value for money. Annual savings of about US$150 million are envisaged through better management of government-financed procurement alone [World Bank 2003]. A key deliverable of the procurement reform was a draft Public Procurement Bill, which was enacted into law by Parliament in 2003. Direct measures also undertaken by Government include: the issuance and monitoring of expenditure ceilings for each MDA consistent with the annual budget and updated cash flow forecasts; and implementing new anti-corruption strategies including codes of conduct for state officials. All procuring entities must seek clearance from the Ministry of Finance, through certification as proof of the availability and adequacy of funding, before any works contract is awarded.

THE PUBLIC PROCUREMENT ACT (ACT 663)

The PPA establishes the five basic pillars of public procurement [World Bank 2003]: (1) comprehensive, transparent legal and institutional framework; (2) clear and standardised procurement procedures and standard tender documents; (3) independent control system; (4) proficient procurement staff; and (5) anti-corruption measures. Some notable provisions in this Act are highlighted below.

Legal and institutional framework

The PPA provides for the establishment of a Public Procurement Board (*the* Board) (s.1) as a legal corporate entity. Procurement entities are defined as comprising MDAs and all para-statal establishments that utilise public funds (s.14). A tender committee in each procurement entity provides a one-stop shop for concurrent approvals, awards and management of contracts to predefined value thresholds (s.17). The tender committee may make use of external consultants in the performance of its functions. The tender committee shall refer any procurement exceeding its value threshold to the appropriate tender review board at the district, regional, ministerial or central government level. The tender review board reviews all procurement activities for compliance with the PPA, provides concurrent approval or otherwise of procurement referrals, hears complaints and escalates unresolved issues to the Board (s.20).

Procurement procedures and documentation

Parts III-V stipulate procedures for the sizing of tender packages, soliciting and evaluating tenders and for contract award. In particular, s.22 provides for the pre-qualification of tenderers for large and/ or complex works and technical services contracts. All contracts must be tendered on an open competitive basis, except otherwise provided for in the Act (s.35). Restricted tendering is justifiable only on the grounds of providing greater economy and efficiency and subject to the approval of the Board (s.38). Two-stage tendering is only allowed where detailed specifications cannot be made available before going to tender (s.36) or the optimal solution is unknown and tenders are solicited to provide this. National Competitive Bidding shall be used when the procurement entity so decides (s.44) and subject to contract value thresholds specified in Schedule 3. International Competitive Bidding shall be used when effective competition cannot be achieved without the inclusion of foreign firms (s.45).

All procurement must use the appropriate standard tender/ contract document provided in Schedule 4 and modifications can only be introduced through tender/ contract data sheets or special conditions of contract (s.50). The successful tender for works contracts shall be the lowest evaluated tender price ascertained on the basis of criteria specified in the invitation documents, which shall include (s.59): (1) the tender price subject to any margin of preference for domestic contractors (s.60); (2) the lifecycle costs of the tendered solution; (3) the potential for economic development, local involvement or technology transfer; and (4) national security considerations. The selection of consultants shall be on quality and cost-based criteria (s.75) with the price component assessed in a similar manner as for works (s.69). Quality-based selection is allowed for complex or highly specialised assignments (s.72), and least-cost selection is reserved for small value assignments.

Procurement oversight, capacity building and anti-corruption measures

The Board's duties include, to (s.3): provide policy and regulatory oversight; provide training and capacity building for procurement officials; hear appeals and complaints; and, assist local industries to become competitive and efficient suppliers to the public sector. The Board shall maintain a database of all suppliers, contractors and consultants and shall debar from procurement practice under the PPA, and publish the list of, all suppliers, contractors and consultants with proven misconduct under the Act. The right to review is provided for in section 78. The head of the procurement entity must first investigate a complaint (s.79) and then, if unresolved within the time frame allowed, the complainant may seek administrative review by the Board (s.80). Third parties whose interests may be affected by the review proceedings are permitted to participate in them. The Board shall establish and publish a code of conduct for all procurement officials, the Board, tender review boards as well as for suppliers, contractors and consultants (s.86). Corrupt practices, as defined in the Constitution and the Criminal Code, 1960 (Act 29), are outlawed under the PPA (s.93). Violation of any provision of the Act, upon conviction, is punishable by a fine not exceeding 1000 penalty units or a term of imprisonment not exceeding five years or both (s.92).

Scope of application

The PPA applies to all procurement financed in whole or in part from public funds (s.14). Notwithstanding this provision, procurement with international obligations arising from any grant or concessionary loan to the government shall be in accordance with the terms of the grant or loan (s.86). However, it has been suggested that the World Bank/ FIDIC procurement procedures are used on World Bank-administered projects because MDAs have no set of comprehensive guidelines for procurement [Westring 1997, World Bank 1996]. There is therefore reason to expect that donor partners will defer to the use of the PPA. The agreement between the Ministry of Health and its cooperating partners, under a World Bank-administered programme, to organise procurement under specific Ministry of Health procedures is perhaps evidence of this expectation [World Bank 2003].

ACHIEVING VfM IN CONSTRUCTION

The five basic pillars of a 'well functioning procurement fiduciary management' are all addressed in the PPA, which if completely implemented will create the necessary conditions for 'best value', transparency and accountability in public sector construction procurement [World Bank 2003]. However, the procurement reforms described above are not, of themselves, sufficient conditions for the achievement of VfM. The 2003 CPAR acknowledges this fact and calls for improved contract management and greater professionalism in the procurement function. The sole reliance upon the traditional method and the use of largely price-based contractor selection criteria seem to be fundamental mistakes [see e.g., Palaneeswaran *et al.* 2001, Rwelamila *et al.* 1999]. The designer's focus on reputation and the contractor's preoccupation with price competition and cost reduction often leads to conflict and lack of cooperation. This lack of cooperation has permeated the various construction professions and academic institutions in the country. The objectives of public implementing agencies tend to be aligned with the traditional method and projects are configured to spend available funds while the longer-term sustainability aspects are often ignored. Rwelamila and

Meyer [1996] demonstrate how this ‘fixed constraints syndrome’ (p.44) has contributed to the poor balancing of project priorities and consequently, poor construction performance in Southern Africa Development Community countries. These trends mean that dramatic changes are required in the way infrastructure projects are procured.

Rationalist procurement theory considers the interplay of time, cost, quality and finance as the primary determinants of value in construction procurement and provides criteria for the selection and use of any particular procurement arrangement [Rowlinson 1999b]. These procurement systems and delivery modalities are, however, not without their limitations. There seems to be a lack of consensus on procurement assessment criteria and, hence, on the relative performance of different procurement paths [Hamilton 1987]. There are inconsistencies in procurement systems definitions and terminology [Rowlinson 1999a]. The procurement selection practices of construction clients’ have been observed to deviate markedly from procurement theory, employing rather simplistic selection criteria and sometimes yielding outcomes that are at variance with procurement theory [Bowen *et al.* 1997]. The procurement arrangements adopted sometimes even defy classification under any of the generic procurement routes [Tookey *et al.* 2001]. Similar debates have shrouded the development of partnering [e.g., Bresnen and Marshall 2000]. However, the literature suggests a growing consensus that there is no ‘best-buy’ procurement solution and that procurement selection should be based on a contingency approach [Rowlinson 1999b].

Whatever the difference of opinion concerning these procurement systems and delivery mechanisms, it is quite clear that relying on a single procurement arrangement is not sufficient to promote the achievement of VfM in public procurement. The proliferation of procurement systems and the many delivery techniques, at least, are a reflection of the determination of the global construction industry to walk towards a brighter future and to address long-known and recognised problems. A structured approach considering all procurement arrangements and project delivery modalities is considered the best way to secure VfM [Kumaraswamy 1998]. The concept of choice, which these alternative systems bring into play, is, of itself, a great advantage as it forces a systematic evaluation of the project requirements, the contextual conditions and risks and thus facilitates ‘best value’-focused decision making. However, our understanding of culture, and the differing motivations for human behaviour it presents, implies that great care needs to be exercised when considering the use of these innovative concepts in construction procurement [Bresnen and Marshall 2000, Hofstede 1980, Muriithi and Crawford 2003]. Nonetheless, these procurement systems and delivery techniques are paradigmatic and with reasoned application can contribute to the realisation of Ghana’s quest for VfM in public construction.

CONCLUSION

The PPA establishes the legal and institutional framework for ensuring transparency, probity and accountability in public construction procurement. The wider reform programme described above will guarantee the rule of law and the protection of private property rights. These reforms create an investor-friendly environment in a country where there is an acute shortage of infrastructure services. Proactive governance and further initiatives are however required to complete the VfM equation. In particular, the ‘fixed constraints syndrome’ and the largely price-based contractor selection strategies will need to be reviewed. Procurement planning and project organisational structures must be tailored to meet particular needs.

The various procurement systems and delivery modalities provide reasonable scope for achieving this objective. The reasoned application of these alternative approaches will contribute to the realisation of Ghana's quest for VfM in public construction. A framework for guiding the implementation of the PPA and other alternative procurement arrangements and modalities will be required to sustain the momentum to reform, and improve the scope for achieving VfM in, the public procurement function. Such a framework has been proposed in Anvuur [2002]. A strongly committed task force, as also suggested by the 2003 CPAR, should be created to support the work of carrying out priority tasks in connection with the proposed framework.

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Development in Public Private Partnerships for construction-based projects in the developing countries

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Abstract
Public-private partnerships (PPPs) provide an avenue for funding major public sector capital projects. This paper documents the extent to which PPP for infrastructure development has emerged in developing countries compared with developed countries. It produces an analysis on the use of PPP in the developing countries based on the database of private sector participation in infrastructure produced by the World Bank. From the analysis it emerged that the private sector participation in infrastructure development in developing countries has mainly been in telecommunication, energy, transport and water sewage schemes. Private sector participation in transport and water is comparatively low, particularly, in the low income developing economies. In addition, PPP investment in low income developing economies is generally very low, representing 9% of the total private sector participation compared with 36% in lower middle income and 55% in the upper middle income. The paper identifies the enabling environment for the developing economies, particularly the low income, to attract private sector investment. The enabling environment includes creation of contractual and legal framework to expedite PPP projects; development of guidelines or framework that promotes PPP contracts; partnering role in procurement process; and PPP strategy that focuses investment in optimum areas.

Keywords
Public-Private partnership, developing countries, service delivery, infrastructure, private finance, public sector

INTRODUCTION

The numbers and types of public private partnerships (PPPs) are overwhelming, making a definition of a PPP difficult. In some cases, city officials might describe a tax concession for which business promises to create jobs in the future as a partnership. In other instances, hiring a private contractor to manage a parking garage or to collect garbage might be labelled a PPP. A partnership might be as extensive as privatising facilities or services, or it might simply involve applying financing or management techniques from the private sector. This idea of bringing in private finance to finance public sector infrastructure originated with the early occurrences of PPP. At the time, the terms “privatisation”, Public Private Partnerships, Alternative Service Delivery and Municipal Service Partnerships were used to mean the same thing.

Public-private partnerships (PPPs) provide an avenue for funding major public sector capital projects. PPPs are joint ventures in which business and government co-operate, each applying its strengths to develop a project more quickly and more efficiently than government could accomplish on its own. The private sector may be responsible for the designing, financing, constructing, owning and/or operating the entire project. The private sector may want to be assured that the public-private partnership structure is designed to provide competitive rates of return commensurate with a financial rate of return that they could earn on alternative projects of comparable risk.

The private-public partnership is now a worldwide significant means of delivering public infrastructure development. This paper documents the extent to which PPP for infrastructure development has emerged in developing countries compared with developed countries. It produces an analysis on the use of PPP in the developing countries based on the database of private sector participation in infrastructure development produced by the World Bank.

RESEARCH METHODS

This paper is based on (i) literature review of PPP, (ii) previous research undertaken by Akintoye et al (2002, 2005) and (iii) an analysis of secondary data from by World Bank: Private Participation in Infrastructure Database (http://ppi.worldbank.org/reports/customQueryAggregate.asp). The World Bank database of PPP infrastructure projects covers PPP projects in developing economies by income from 1983 to 2003. Only three countries from Sub Saharan Africa (Botswana, Gabon and South Africa) are among the upper middle income economies that include Malaysia, Brazil, Poland and Libya. Thirty four (34) of the low income developing economies are located in Sub-Saharan Africa and two (2) in the lower middle income. The database covers four infrastructure sectors: (i) energy (electricity generation, transmission, and distribution and natural gas transmission and distribution; (ii) telecommunications (fixed or mobile local telephony, domestic long-distance telephony and international long-distance telephony); (iii) transport (airports runways and terminals; railways fixed assets, freight, intercity passenger, and local passenger; toll roads, bridges, highways, and tunnels and seaports channel dredging and terminals); and (iv) water (potable water generation and distribution and sewerage collection and treatment). The database considers projects to have private participation if a private company or investor bears a share of the project's operating risk. The database classifies private infrastructure projects into four categories: management and lease contracts; concessions (or management and operation contracts with major private capital expenditure); greenfield projects; and divestitures. This paper is restricted to an analysis of private participation from 1990 to 2003.

AN OVERVIEW OF PUBLIC PRIVATE PARTNERSHIPS

PPP can be described as a contractual agreement of shared ownership between a public agency and a private company, whereby they pool resources together and share risks and rewards, to create efficiency in the production and provision of public or private goods. It can be argued that it is difficult to have a unified definition of PPP, although all definitions have common features or characteristics. This has led Peters (1998) to identify five general defining features of Partnerships which are very common to public private partnership, namely:

1. A partnership involves two or more actors, at least one of which is public and another from the private business sector. Tarantello and Seymour (1998) suggest that partnerships between non-profit organisation and local governments should also be counted as PPPs.
2. In a PPP, each participant is a principal, i.e., each of the participants are capable of bargaining on its own behalf, rather than having to refer back to other sources of authority. Grimsey and Graham (1997) noted that, in some instances, the public sector has to set up a special agency capable of entering into partnership before collaboration becomes possible.
3. Another feature of partnerships is that they establish an enduring and stable relationship among actors. In a PPP there is a need for continuing relationship and the parameters which are negotiated among the members from the outset and a process in which such a partnership is created (Moore and Pierre, 1988).
4. In a PPP, each of the participants brings something to the partnership. Therefore, for the partnership to be a genuine relationship, each will have to transfer some resources – material or immaterial – to the partnership.
5. A partnership implies that there is some shared responsibility for outcomes or activities (Collin, 1998). This differs from other relationships between the public and the private sectors in which the public sector retains control over policy decisions after receiving the advice of organisations in the private sector. Partnerships often are separate organisational structures, rather than bargaining relationships which have been established among otherwise autonomous organisations. Grant (1996) argues that shared authority and responsibility, joint investment, sharing liability/risk-taking and mutual benefit stand at the core of a partnership.

PPP can take different forms, as in the case of UK government that has identified about seven PPP models (HM, 2000). The level of private sector involvement might range from a purely service provision, without recourse to public facilities, through service provision based on public facilities usage, up to "public facilities" ownership. Gentry and Fernandez (1998) noted the form adopted depends on such issues as: the degree of control desired by the government; the government's capacity to provide the desired services; the capacity of private parties to provide the services; the legal framework for monitoring and regulation; and the availability of financial resources from public and private sources. For example, South African PPP excludes an agreement between an institution and a private party, where the latter perform an institutional function without accepting the significant risks (South Africa Government Gazette, 2000).

Li and Akintoye (2003) have identified the benefits of PPPs to include: enhancing government's capacity to develop integrated solutions; facilitating creative and innovative approaches thus reducing the cost to implement the project; reducing the time to implement the project; transferring certain risks to the private project partner; attracting larger, potentially more sophisticated, bidders to the project; and providing avenue to access skills, experience and technology.

PPP IN THE DEVELOPED ECONOMIES

The use of PPP in developed economies has being the subject of rigorous research investigation. For example, based on case studies of transport PPP projects in Europe, Jones (1998) documented INFRAFIN project (Contract No: ST-97-SC.121) which was funded by the European Commission under RTD programme of the 4th Framework programme to examine issues in the planning, financing and operation of major transport infrastructure projects, whether undertaken as public-private partnerships (PPPs) or as traditional publicly financed schemes. Poole, Jr. (1995) reported the need for PPP in America to empower cities and states to tap private capital and rebuild America. In addition Poole, Jr. (1995) noted the case for PPP including new source of capital, time saving, capital saving, risk reduction and new tax revenues. In addition, he noted that 'an added benefit of encouraging investor-owned infrastructure in America would be the development of world-class U.S. infrastructure firms'. Li and Akintoye (2003) report the pattern in the use of PPP across continents. What is noticeable in their study is that, while PPP is used predominantly in public sector infrastructure developments in the developing economies, it is used in the developed economies to deliver various government public services, goods and facilities.

In UK for example, it has been used on different types of projects including schools, education facilities, car parks, airports, leisure, hospitals, rail, tram, roads, bridges, prisons, equipment, waste management and water. Despite this, private sector investments have mostly been in four sectors: transport, health, defence and school. Combined projects in these four sectors represent 51.12% of the total number of the signed PFI projects and 78.16% of the total capital value. The transport sector has the highest share of the PFI schemes undertaken in the UK in terms of value of schemes. Although transport PPP projects are responsible for less than 6% of the signed projects, they account for about 50% of the capital value. The average capital value of projects in this sector is £368m, with 74% of the schemes over £50m capital value. Locke (1998) argues that the interest in transport schemes is attributable to a large backlog of road and bridge projects held 'on-the-shelf' plus interest in light rail or guided bus schemes. Most road and bridge PFI schemes in England are sponsored centrally by the Highways Agency under the Department of Transport. The total PFI investment in transport PFI schemes between 1989 and 2003 was £15b. Since then many new transport PFI schemes have been signed. It is expected that the investment in road PFI schemes will increase now that the local authorities are venturing into road maintenance PFI. The first local authority road PFI is the £500m Portsmouth City Council highways maintenance PFI contract that was awarded in early 2004 (see Akintoye et al (2005) for a comprehensive analysis of the PPP trends in the UK).

ANALYSIS OF THE PPP IN INFRASTRUCTURE DEVELOPMENT IN THE DEVELOPING ECONOMIES

PPP in the developing countries has not developed to the extent where they are used to deliver different types of public sector services, goods and facilities compared to the way it is being used in developed countries (Li and Akintoye, 2003). For example, Jütting (1999) has shown using case studies how the implementation of PPP in the health sector, although theoretically appealing, is still not very common in developing countries. This emanates from the level at which many developing economies, particularly low income countries, are operating primarily to provide basis essentials of life: food, shelter and water. In addition, many developing countries depend on extraction and exportation of agricultural and raw natural resources to support the economy. The implication is that the basic infrastructures that are needed are those essential to support these basis essentials of life and to extract and export agricultural and raw natural resources.

The infrastructures mainly needed by the developing countries to support their economic activities are those related to transportation, energy and portable water, and most recently, telecommunication. Although these are needed, many developing countries cannot afford them without affecting other economic activities because of cost considerations (initial capital outlay and cost of operation and maintenance) and lack of appropriate technology to support them. Level and efficiency of productivity have also been identified as factors militating against infrastructure performance in developed economies. All these have opened avenues for consideration of PPPs in developing economies to design, construct, operate, maintain and finance infrastructure development in form of management and lease contracts, concessions and divestitures.

The Institute of International Project Financing (IIPF) produced a list of how PPP project finance has been used internationally (IIPF, 2005). According to IIPF, whether termed "international project finance," "global project finance" or "transitional project finance," the financing technique of bringing together development, construction, operation, financing and investment capabilities from throughout the world to develop a project in a particular country is very successful. The technique is being used throughout the world, in emerging and industrialised societies. Examples of facilities developed through public-private partnership project financing include (IIPF, 2005):

- Energy Generation: This is for construction of new energy infrastructure and presents an alternative to the traditional, non-market-based development of electricity resources and allows private generation of electricity through various models: privatisation of existing assets, encouragement of private development of new electrical production, and establishing the government-owned utility as a purchaser of power for transmission and distribution over existing facilities, or a combination of these.
- Pipelines Developments: This allows large natural gas pipelines and oil refineries to be developed through this model rather than being financed either by the internal cash generation of oil companies or by governments.
- Mining Development: Projects financed through PPPs are commonly used for mining operations in many developed and developing countries.
- Toll Roads: The capital-intensive nature of these projects, in a time of intense competition for limited governmental resources, makes PPP project finance based on toll revenues particularly attractive. This is used in many Asian countries including Thailand, India and Malaysia.
- Waste Disposal: PPP has become an attractive financing vehicle for household, industrial and hazardous waste disposal facilities.
- Telecommunications: According to IIPF, the information revolution has created enormous demand for telecommunications infrastructure in developed and developing countries. Telecommunication projects are a growing area in Sub-Sahara Africa in countries like Nigeria, Cameron, Angola and Burkina Faso. Nigeria alone has seen private investment of about US$2636 million in its telecommunication sector between 2000 and 2003 compared with Cameron US$234million, Angola US$158.9 and Burkina Faso US$158.6million over the same period.

Table 1 and Figure 1 show the World Bank figures on the private sector investment in infrastructure in these sectors between 1990 and 2003, with the main investment being in telecommunication sector followed by the Energy sector. The figures show that the Sub-Sahara Africa has not benefited much from PPP compared with Latin America, the Caribbean, East Asia and the Pacific regions that have continuously used PPP to deliver public sector infrastructure.

Figures 2 show the private sector investment in infrastructure in developing economies based on the sector segments. These figure shows that telecommunications (fixed access, mobile access, and long distance) and electricity (generation, transmission, and distribution) followed by toll-roads (bridge, highway, and tunnel) are the major segments for private sector investment in developing economies. Portable water is not popular with the private sector although this is an infrastructural area that many developing countries, particularly the low income countries, need help with investment and knowledge transfer.

Table 1. Sectorial private sector investment in infrastructure 1990 -2003 (US$ millions)

Primary Sector	EAS	ECA	LAC	MENA	SA	SSA	Total
Energy	71,522.90	31,631.60	118,841.60	11,794.70	20,258.50	6,175.00	260,224.30
Telecom	53,243.10	78,900.50	171,390.10	15,500.20	21,436.10	21,723.60	362,193.60
Transport	46,649.80	4,719.60	63,894.00	2,425.50	3,115.20	2,748.90	123,553.00
Water and sewerage	15,311.90	3,327.40	19,465.30	1,236.50	216	229.8	39,786.90
Grand Total	186,727.70	118,579.00	373,590.90	30,956.90	45,025.70	30,877.30	785,757.50
	23.76%	15.09%	47.55%	3.94%	5.73%	3.93%	100%

Source: Based on an analysis of the World Bank database (2005)

Note: (i) EAP - East Asia and Pacific; ECA - Europe and Central Asia; LAC - Latin America and Caribbean; MENR - Middle East and North Africa; SA - South Asia; and SSA - Sub-Saharan Africa

Figure 1. Percentage analysis of sectorial private sector investment in infrastructure (1990-2003)

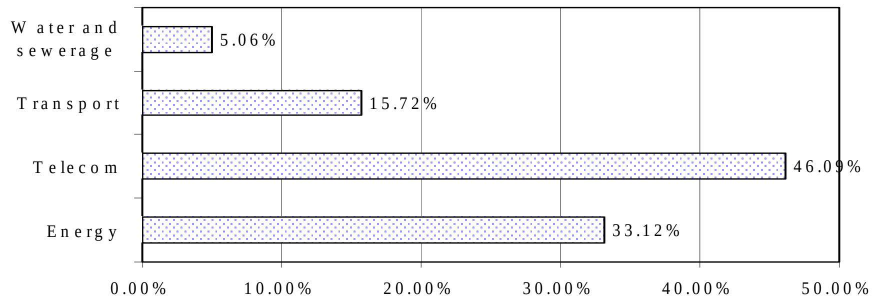
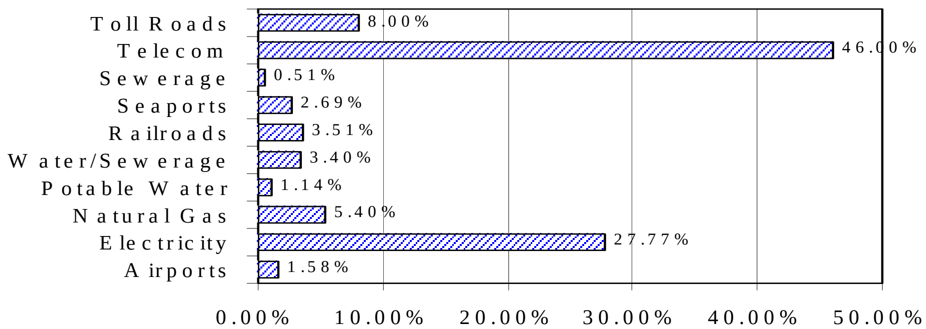


Figure 2: Percentage analysis of segmental project investment in Infrastructure 1990 -2003



ANALYSIS OF PPP IN THE TRANSPORT SECTOR

Table 2 and Figure 3 present the World Bank data analysis of capital investment by the private sector in transport sector (i.e. road, railway, seaport and airport). Transport has been chosen as a major sector that investment is needed in the developing economies (apart from water sector) but in which PPP has not been particularly tapped. Table 2 shows that private sector investment in transport in Sub-Sahara Africa is 2.53% of the total transport investment compared with 50.44% in Latin America and the Caribbean and 38.18% in East Asia and the Pacific. In addition, the number of transport schemes in Sub-Sahara Africa is less than fifty (50) and the schemes are typically small (about US$77milion per scheme) compared with many (283 and 220) and larger (US$184million and US$179 million per scheme) schemes in Latin America and the Caribbean and East Asia and the Pacific respectively. The transport sector investment is 8.9% of the total private investment in infrastructure in Sub-Sahara Africa compared with 70.4% in telecommunication and 0.74% in water.

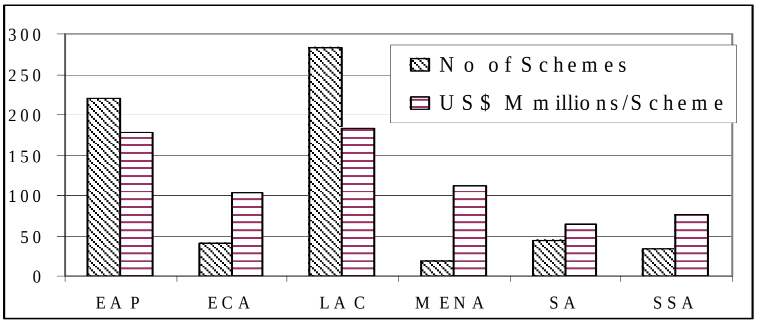
The main countries in the East Pacific and Asia where there is huge private sector investment in transport, apart from China, are Malaysia, Indonesia, Thailand and the Philippines. In these four countries, about 40% of the private sector investment in transport is in highways compared with terminal (22%), urban passenger (18%) and freight (15%). Private sector investment in transport in Latin America and the Caribbean comprises of 53% in highway, 21% in terminals and runways, 17.3% in freight and 8% in urban transport. Although transport investment in the Sub-Sahara Africa is low, the majority of this is in highway transport (61%) which supports the fact that many countries in Sub-Sahara Africa have low income compared with East Asia and the Pacific and Latin America and the Caribbean countries that have achieved diversified private sector transport investment.

Table 2: Private sector participation in transport sector projects (1990 – 2003)

	EAP	ECA	LAC	MENA	SA	SSA
1990	289		1,435.60		1.9	
1991	1,956.20		257.4			
1992	879.9	0	1,406.10			
1993	1,334.50	3.1	1,891.60			30.8
1994	4,001.80	634	2,273.00		125	18
1995	3,711.40	263.7	2,786.40		299.6	
1996	8,188.70	106.2	6,557.30		107.2	28
1997	6,424.50	305	8,377.70	297.5	549.3	468.6
1998	1,939.90	1,224.30	13,212.90	123.9	294.4	320.6
1999	2,163.70	356.5	3,739.50	207	661.9	1,045.70
2000	3,016.10	882.2	4,426.30	466.9	100.3	43.2
2001	3,364.80	333.6	3,850.20	905	100	504.3
2002	165.2		988.1	20	495.9	
2003	1,840.20	121	681.4	5.2	114.5	142.5
Total	39,275.90	4,229.60	51,883.50	2,025.50	2,850.00	2,601.70
%	38.18%	4.11%	50.44%	1.97%	2.77%	2.53%

Source: Based on an analysis of the World Bank database (2005)

Figure 3: Project investment in Infrastructure 1990 -2003 in terms of project count and size



AN ENABLING ENVIRONMENT FOR PRIVATE SECTOR INVESTMENT IN PUBLIC SECTOR PROJECTS IN DEVELOPING COUNTRIES

The analysis of the World Bank data has shown that there is low private sector investment in transport and water schemes compared with telecommunication, particularly in the low income developing economies. However, it would appear that these two sectors (transport and water) are in dire need of this investment. Overall the low income developing economies have insignificant private sector involvement in public sector facilities (in terms of project investment and project count) compared with lower middle income and upper middle income developing economies (see Table 3).

Table 3: Private sector participation in infrastructure: low, low middle and upper middle incomes

	Low income	Lower middle income	Upper middle income
Total Number of Countries	59	49	30
Project Investment (US$ Million)			
Energy	29,569.90	107,174.40	127,809.40
Telecom	33,350.80	118,658.90	210,183.80
Transport	5,330.90	42,526.60	76,571.50
Water and sewerage	621.1	16,112.50	23,053.30
Grand Total	68,872.60	284,472.40	437,618.00
Percent	8.71%	35.97%	55.33%
Project Count			
Energy	159	555	407
Telecom	189	253	158
Transport	97	299	341
Water and sewerage	13	108	140
Grand Total	458	1215	1046
Percent	16.84%	44.69%	38.47%
Investment/Scheme (US$ million)	150.38	234.13	418.37

Source: Based on an analysis of the World Bank database

Table 3 shows that the low income developing economies associated with 59 countries in this category have 8.91% of private sector infrastructure project investment and 16.84% project count compared with 49 lower middle income countries with 35.97% project investment and 46.69% project count and 30 upper middle income countries with 55.33% project investment and 38.47% project count. About one-third of the projects count in the low income developing countries are in India (130 projects out of 458). This might suggest that the middle income (lower and middle) developing economies must do something unique or have some special features that is not the case in low income countries which encourage private sector project investment in infrastructure in these countries.

There are some enabling factors noticeable in the developed and upper middle developing economies that are essential for private investment in infrastructure development in developing countries. These include: creation of contractual and legal frameworks to expedite PPP projects; development of guidelines that promote PPP contracts; partnering role in procurement process; and PPP strategy that focuses investment in optimum areas

The need for this enabling environment is recognised by the Botswanan government that has seen PPP as one of the main methods chosen for the delivery of public sector services and facilities. This is informed by an increase in the government commitment to services and the health of the national economy and the need to gain efficiency in the delivery of public service. The government has entrusted PPP programme in Botswana to its Public Enterprises Evaluation and Privatisation Agency (PEEPA). To this effect, PEEPA has recently advertised to procure the services of reputable and experienced consultants to develop the strategic implementation framework for Public Private Partnership (PPP) in Botswana. The strategic implementation framework is intended to create a favourable environment that will facilitate PPP project implementation, provide comfort to potential investors in PPP projects, and guidance and direction to implementing Government agencies. The key elements of the framework will be, amongst others, a clear guiding policy, appropriate legislation, an institutional set up capable of efficient implementation and facilitation of PPP projects, as well as standard procedures and guidelines for setting out the process to be followed in implementing PPP projects.

Li and Akintoye (2005) have also identified some critical success factors based on the UK PPP/PFI study that shows that effective procurement, project implementability, government guarantee, favourable economic conditions, and available financial market are essential for PPP to thrive. Jütting (1999) identified macro level conditions in favour of setting up of a PPP: these include a political environment supporting the involvement of the private sector, an economic and financial crisis leading to pressure for the public sector to think of new ways of service provision, and a legal framework which guarantees a transparent and credible relationship between the different actors. At the micro level, the capacities of the actors, e.g. their personal interest, skills and organisational and management structure are identified as being important (Jütting , 1999).

CONCLUSIONS

From the results of the analysis of the World Bank data it is evident that private sector investment in infrastructure in developing economies is a major source of investment for delivery of public sector services in the developing economies. Private sector investment has been mainly in telecommunication and energy sectors rather than transport, water and sewerage. The energy sector private investment is mainly in the electricity generation, transmission, and distribution. Although the low income countries constitute the bulk of developing economies, private sector investment in infrastructure in this category of countries is very insignificant compared with middle income countries. The amount of private sector participation in infrastructure in Sub-Sahara Africa is comparatively low.

However, the private sector investment in public sector infrastructure development has some benefits that the developing countries need to tap. This will enable the governments in developing countries to develop capacity for integrated solutions for infrastructural development, reduce time and cost to deliver projects; reduce risk associated with infrastructure projects, attract larger and potentially more sophisticated project sponsors and achieve technology and knowledge transfer. To achieve this, an enabling environment needs to be created in the form of appropriate guidelines, contractual and legal frameworks to promote PPP, government guarantees and stable economic, social and political environment, and a PPP strategy that focuses investment in optimum areas.

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Dispute boards on international infrastructure projects: implications for the construction industries in developing countries

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Abstract
Although an alternative to litigation, arbitration has grown as time-consuming, expensive and destructive of relationships. In the mid-1990s FIDIC and the World Bank introduced the concept of dispute resolution by a decision-making Dispute Board (DB), which is a panel of three members independent of the owner and the contractor. Any dispute arising from the project between the owner and the contractor is referred to the DB for a decision, with which the parties must comply. The concept of DB is critically examined and practice in developing countries is compared with experience of related dispute resolution procedures in the UK and the USA. Issues are raised in relation to cost-effectiveness of DBs, suitability of professionals in the developing countries for appointment to boards, availability of training and how the decision of a private panel can be enforced in an international setting.

Keywords
Contract administration, dispute resolution, FIDIC, international contracting, World Bank.

INTRODUCTION

The construction industry is notorious for disputes that not only damage the quality of relationships in the supply chain but also increase costs. There have been attempts to minimize litigation by incorporating arbitration clauses into standard forms of construction contracts. However, arbitration has become just as time-consuming, expensive and destructive of relationships as litigation [Pike 1993a, 1993b, Latham 1994, Matyas *et al.* 1995]. As a result, a range of resolution techniques has been introduced, referred to collectively as "Alternative Dispute Resolution" (ADR). These include mediation, conciliation and mini-trial (a.k.a. executive tribunal). The concept of a Dispute Review Board (DRB) has been part of these developments. A DRB is a panel of three members of recognised knowledge, experience and professional standing in relation to construction disputes, jointly appointed by the contractor and the employer on a construction project. The role of the panel is to make recommendations on how any dispute that arises from the project is to be resolved by the contractor and the employer. To allow them to perform this function the DRB keeps abreast of project matters through regular visits to the site and being supplied with key project documents such as drawings, minutes of site meetings, instructions from the contract administrator and notices.

The concept of "adjudication" was introduced in the UK in the 1970s, initially for payment disputes between main contractors and their sub-contractors. It required a referral to an independent third party who could decide either (i) that the main contractor was to make the disputed payment, (ii) that the sub-contractor was not entitled to the payment or (iii) that the disputed payment was to be made to a trustee stakeholder account pending amicable settlement or an arbitration award on the dispute. In 1996 the UK Government, on the recommendation of a committee set up to improve the construction industry, enacted the Housing Grants, Construction and Regeneration Act 1996 (HGCRA) making adjudication a statutory provision in all construction contracts. An adjudicator's decision is binding on the parties until final resolution of the dispute.

The World Bank (WB) introduced dispute resolution by a DRB into the 1995 version of FIDIC's Red Book that formed part of its standard bidding documents [World Bank 1995]. This type of DRB had the distinction that a recommendation became binding only if no party served notice of dissatisfaction with it within 14 days after receipt.

FIDIC, the international federation of institutions of consulting engineers, in 1996, introduced a Disputes Adjudication Board (DAB) that makes immediately binding decisions pending final resolution by amicable settlement, arbitration or litigation. If neither party serves notice of dissatisfaction with the decision within 28 days it becomes finally binding. The FIDIC DAB was first specified for use in the conditions for Design/Build and Turnkey (the Orange Book). In the same year FIDIC published a Supplement to the 4th edition of its Red Book, which also offered DAB instead of the Engineer as the first resolution method for disputes. The DAB shared with the US-style DRB the common features of a tribunal of three members and cotemporaneous dispute resolution. All the current FIDIC contracts except the Green Book provide for dispute resolution by DABs.

DB is here to stay. Based on the success of US-style DRB, it has been adopted widely on major projects with positive results [Matyas *et al.* 1995, Shadbolt 1999, Jaynes, 2002]. The most potent force behind the expansion is the fact that World Bank and other Multilateral Development Banks (MDBs) have adopted into their procurement procedures a version of the 1999 FIDIC Red Book that retains the DAB concept except that it is referred as a "Dispute Board" [FIDIC 2005]. For simplicity, the term "Dispute Board" (DB) is hereafter used to refer to any type of decision-making DRB/DAB.

AIMS AND OBJECTIVES

Experience of decision-making DBs is still very limited. That a DB cannot enforce its decision is its closest link with UK-style adjudication, on which there is a considerable body of knowledge. Further action would always be needed to implement a decision compulsorily if a party declines to comply. In adjudication the enforcement procedure is to bring proceedings in a state court. The aim of this paper is to examine the characteristics of the resolution technique and to compare it with US-style DRBs and UK-style adjudication, similar resolution techniques for which there is established practice. The purpose is to identify and evaluate implications for DB in developing countries. The analysis of reported cases in this paper has concentrated on adjudication practices and procedures, grounds upon which losing parties in adjudication proceedings have sought to resist subsequent enforcement of the adjudicators' decisions and the way the courts have decided the validity or otherwise of the defences.

We consider only two of the likely obstacles to cost-effective enforcement. These should inform not only DB practice but also the drafting of special conditions on DBs. The first issue concerns access to an appropriate court for enforcement action. The second issue is associated with the likelihood of losing parties contesting enforcement even where the first issue is resolved in favour of enforcement. As an alternative to enforcing a DB decision by issuing court proceedings, failure to comply may be referred to arbitration. We also examine this alternative. The significance of these issues cannot be appreciated fully out of the context of the legal and financial framework of the FIDIC-style DB. An outline of this framework follows.

THE FIDIC-STYLE DISPUTE BOARD

The MDB Red Book is a specifically amended version if the FIDIC Red Book. The contract mandates the establishment of a DB. Unless the General Conditions are amended dispensing with this requirement, it must be formed by a date specified in the Contract Data, by the joint action of the Contractor and the Employer so that each member of the DB has even allegiance to both parties in relation to his appointment. A DB may comprise one or three members, depending on the size of the project. The Employer, the Contractor and each member of the DB must enter into a contract for which a sample form is provided in the MDB Red Book. The form is referred to as the "Dispute Board Agreement" (DBA). This covers payment and processes, e.g. the Contractor and the Employer share the costs evenly, DB members must be fluent in the language for communications under the contract and they must be "professionally experienced in the type of construction involved in the Works and with the interpretation of contractual documents".

Because of the international nature of this kind of construction work, there are many countries whose courts could potentially have jurisdiction: the parties' nationalities, the parties' domicile, the country in which the works are to be carried out, in which the contract came into being or that specified in the contract. A losing party's response to proceedings on a DAB decision may be that the court has no jurisdiction. It is then for the court to decide whether it has jurisdiction by applying the jurisdictional rules of the court's own legal system. A further point to bear in mind is that obtaining judgment in support of the DAB's decision would be a Pyrrhic victory if the losing party has no assets within the jurisdiction of the court against which the decision can be enforced.

A DB decisions may be referred either because it has become finally binding due to neither party serving notice of dissatisfaction within 28 days or a valid notice of dissatisfaction has been served.

Finally binding decisions

An arbitration tribunal would have very little to do where the dispute referred is a monetary DB decision; it only has to write an award directing the amount to be paid by the party to whom it is addressed. Barring the time taken by procedures of arbitration institutions, there is no reason why such an arbitration award should not be obtained very speedily.

Decisions subject to notice of dissatisfaction

There are two alternative approaches to reference subject to notice of dissatisfaction. First, a failure to comply with the decision may be referred. The question to be decided by the arbitration tribunal would then be simply the validity rather than the merits of the decision. If the arbitration tribunal determines that the DB made a valid decision it must make an award for the amount that the DB decided was payable. The main flaw in this approach is that in some jurisdictions no further proceedings can be brought on the substantive dispute. Alternatively, the original dispute may be referred to arbitration and an application made for an interim award in the amount decided by the DB. Such an award would be subject to review in the final award. This strategy raises complex issues as to the enforceability of interim arbitration awards.

DEFENCES AGAINST COURT ENFORCEMENT OF DB DECISIONS

The decision of a DB shares attributes with UK-style adjudication, particularly in two respects. First, the decision-making power is created by the underlying contracts between the parties. Second, these contracts provide that the parties must comply with the decision until the dispute is finally resolved by agreement, arbitration or litigation. The fact that there are three members on a DB is not relevant because the DB concept contemplates a one-member board. It is therefore arguable that any defence that has been effective against the decision of a UK-style adjudicator should also be effective against the decisions of a DB.

However, there are differences that may have implications on the deployment of these defences against the enforcement of the decision of a DB:

1. Although the obligation to comply with the decision is contractual in both cases there is statutory force behind the decision of an adjudicator.
2. While a DAB is set up at commencement of construction and maintained until after handover, an adjudicator is appointed only for the purposes and duration of a dispute when it arises.
3. There is an international context to the enforcement of the decision of a DB.
4. The decision of a DB is admissible evidence in any subsequent arbitration proceedings.

A variety of defences have been argued against enforcement of the decisions of adjudicators. Analysis of the relevant cases reveals that enforcement can be successfully resisted on any of the following grounds:

- **Lack/excess jurisdiction:** It is now accepted that the decision of an adjudicator reached without or beyond jurisdiction is void. An adjudicator's power stems from the contract between the parties. Thus the party seeking enforcement must provide acceptable evidence that there was a qualifying contract from which the dispute arose. Unless this is done, no court will enforce the decision. Even where a contract is admitted or found to exist, jurisdiction may be challenged on any of the following grounds: the adjudicator's appointment was not in accordance with the procedures in the contract; there was no dispute in relation to the matter decided by the adjudicator; although there was a dispute between the parties, the matters decided by the adjudicator are not responsive to the issues in dispute; the adjudicator failed to make the decision within the applicable contractual timetable; the matters decided had already been decided in an earlier adjudication. These arguments have provided a fertile ground for litigation in connection with attempts to enforce decisions of adjudicators. Some adjudication procedures provide that the adjudicator has the power to rule on his or her own jurisdiction if it is challenged. The courts have decided that where an adjudicator has been given such power, the decision cannot be challenged on jurisdictional grounds. Under Rule 7 of the Procedural Rules governing DB procedure under the MDB Red Book the DB has the power to decide its own jurisdiction and the scope of any dispute referred to it. However, the decision would still be subject to challenge if it was delivered later than required under contract.

- **Breach of natural justice and procedural unfairness/irregularity:** Natural justice is an obligation on a court or other tribunal to do justice by all the parties to the dispute before it. It is a fundamental principle of English law and many other legal systems. There are two rules within the general natural justice principle. First, a tribunal must not be biased. Second, the procedures of the tribunal must be such that each party is given a reasonable opportunity not only to put forward its case but also to understand and challenge the case against it. Certain express powers given to the DB under Rule 8 of the Procedural Rules could have some resonance on the question of whether the DB has a duty to comply with the rules of natural justice. These are the powers to: establish the procedure to be applied in deciding a dispute; conduct any hearing as it thinks fit, not being bound by any rules or procedures other than those contained in the Contract and these Rules; take the initiative in ascertaining the facts and matters required for a decision; make use of its own specialist knowledge, if any. These powers could be read as powers to ignore the rules of natural justice. However, if the intention was to free the DB of the shackles of natural justice, then such an intention could have been expressed more clearly. In particular, the freedom not to be bound by any rules or procedures refers only to the conduct of a hearing. Such freedom may not exist in relation to the rest of the process. Indeed, Rule 5 of the Procedural Rules requires the DB to act fairly and impartially. On balance, a DB should have regard to requirements of natural justice.

- **Insolvency of payee:** It is settled law that the decision of a UK-style adjudicator must be enforced even if it is palpably wrong in law or fact: *Bouygues UK Ltd.* v. *Dahl-Jensen UK Ltd* [2000] BLR 49 (TCC) [2000] BLR 522(CA). This is justified by the proposition that any mistakes made by the adjudicator can always be corrected by referring the same dispute to arbitration or a court of law. But this would be near impossible if the beneficiary of the decision is insolvent. There have been decisions in which the court recognised the effectiveness of a challenge to enforcement on the grounds that, on account of insolvency, the payee would be unable to make repayment if final resolution of the dispute necessitates it. Strong evidence of insolvency is needed; mere fears that the payee might not unable to repay are insufficient. The issue of insolvency defence is analysed in detail by Ndekugri and Russell [2005]. The insolvency challenge is effective against enforcement of adjudicator's decisions because of English insolvency legislation. Whether such a challenge is effective against enforcement of DB decisions cannot therefore be inferred from the English law position.

- **Set-off against the adjudicator's decision:** The argument here is that the paying party may exercise a right under the contract to withhold part or all of the amount to be paid. This is a question on which there has been stark disagreement among UK judges. The proposition applied in one group of cases (e.g., *KNS Industrial Services (Birmingham) Ltd. v. Sindall Ltd.* (2001) 17 Const LJ 170 and *David McLean Housing Contractors Ltd. v. Swansea Housing Association* [2002] BLR 125) is that, as the obligation to comply with an adjudicator's decision is contractual, any other contractual provision that entitles the paying party not pay could prevail over the obligation to pay the amount ordered by the adjudicator. A contrary proposition is offered by other cases (e.g., *Levolux A.T. Ltd. v. Ferson Contractors Ltd.* [2002]

BLR 34, *The Construction Group Centre Ltd. v. The Highland Council* [2002] BLR 476 and *Balfour Beatty Construction v. Serco Ltd.* [2004] EWHC 3336) that an adjudicator's payment decision creates a special type of debt that must be settled without recourse to set-off or counterclaims. It is not surprising therefore the question of availability of set-off has been argued before the Court of Appeal several times. No direct answer has been given because the issues in dispute did not require it. However, it is fair to conclude that the tenor of the Court of Appeal's judgments has been that there is no right of set-off. This proposition has been justified on the ground that to allow such set-off would frustrate the underlying aim of improving cash flow on construction projects.

- **Corrected decision on the same dispute:** This argument arises where an adjudicator accepts that he or she was in error and issues a corrected decision. The question is whether the original decision can be enforced. It has been held that provided the correction is made within a reasonable time original decision should not be enforced: *Bloor Construction (UK) Ltd.* v. *Bowmer Kirkland (London) Ltd.* [2000] BLR 314, *Edmund Nuttall v Sevenoaks District Council* (decided in TCC on 14th April 2000), *CIB Properties Limited v. Birse Construction* [2004] EWHC 2365. It has been suggested up to two weeks after the decision is not unreasonable. It has to be noted that the adjudicator has power to correct only genuine accidental errors, e.g., arithmetical and clerical errors, and that there is no power to revisit the basis of the decision. It is submitted that a DB would have the power to correct this type of error. However, considering that the DB has 84 days to make its decision, as compared to 28 days in the case of adjudication, what is a reasonable period could be a matter of controversy.

- **The decision is wrong:** This defence refers to the situation where there is an error that the adjudicator has not corrected. It has been rejected on the grounds that to allow it would defeat the purpose of the adjudication legislation. This purpose has been stated repeatedly in the case law, e.g., *Bouygues v. Dahl-Jensen,* as improvement of cash flow on construction projects. This purpose would be undermined if parties were allowed to enter into litigation as to whether the adjudicator's decision is wrong. The courts have stated repeatedly that to support the legislation the parties must adopt towards an adjudicator's decision a policy of "pay now, argue later". The lack of statutory force behind DB decisions would make enforcement of a demonstrably wrong decision extremely controversial.

- **Stay of enforcement proceedings to arbitration/litigation:** Under Article II(3) of the New York Convention and Article 8 of the Model Law on International Commercial Arbitration of the United Nations Commission on International Trade Law (UNCITRAL) a court before which an action is brought on a matter within an arbitration agreement must, if a party to the action so requests, stay the court proceedings to arbitration. The only exception allowed is where the arbitration agreement is "null and void, inoperative or incapable of being performed". The English Court of Appeal has stated repeatedly that any action brought in breach of an arbitration agreement must, on the application of the party opposing the action, be stayed to arbitration even if it is clear to the court that the opposing party has no defence in fact or law to the underlying claim (see, for example, *Halki Shpping Corporation v. Sopex Oils Ltd.* [1998] 1 WLR 726 and *Collins (Contractors) Ltd. v. Baltic Quay Management (1994) Ltd.* [2004] EWCA Civ 1757). However, applications to stay court proceedings to enforce adjudicators' decision to arbitration pursuant to the arbitration Act have so far failed (see, for example, *Macob v. Morrison, Absolute Rentals Ltd. v. Gencor Enterprises Ltd*, (2001) 17 Const LJ 322; *The Construction Group Centre Ltd. v. The Highland Council* [2002] BLR 476; *David McLean Housing Contractors Ltd. v. Swansea Housing Association* [2002] BLR 125). Unfortunately, the rationale for the failure of such applications is far from clear although there is little doubt that the statutory basis of UK adjudication is a factor. The effect of an application to stay court proceedings would depend on the applicable arbitration law and the court's application of it. The arbitration agreement in the Red Book is unlikely to be found "null and void, inoperative or incapable of being performed". Where the court is in a country that is signatory to the New York Convention or which has implemented the UNCITRAL Model Law or at least Article 8 of the Model Law, it is arguable that it must stay the proceedings to arbitration.

DISCUSSION

Experience of US-style DRBs up to the 1996 was that average DRB costs were in the range of 0.1-0.3% of final project costs (Matyas *et al.* 1996). Experienced practitioners report a spiral of increasing sophistication and comprehensiveness in the quality of submissions and DRB members have tried unsuccessfully to curb this trend in the interests of economy. The motivation for this excess preparation is probably the fact the DRB recommendation is admissible evidence in subsequent proceedings. As such types of submission have not been part of DRB tradition, the estimated cost of the US-style DRBs may no longer be accurate.

In comparing the US-style DRB process against the FIDIC-style DB, an important distinction to bear in mind is that while a DRB generally makes a recommendation on entitlement in principle only, the DB makes a decision not only on entitlement but also on quantum. Many other factors may impact on the cost-effectiveness of the DB process, particularly in developing countries.

Advice by the board

There are contrasting views on the propriety of a US-style DRB giving advice to the parties. For example, whilst the DRB Manual states that a DRB's ability to offer informal advice would enhance its utility (Matyas *et al.* 1996: 54-55), a US report of the Technical Committee on Contracting Practices of the Underground Technology Research Council [1989] counsels that a DRB ought not to give such advice because it may subsequently have to decide a dispute touching on the subject matter of the advice. Decision-making boards have been known to offer informal advice to parties without any serious negative impact on performance the DB role. Bowcock [1997], a one time Chairman of FIDIC's Contracts Committee, wrote that informal advice given by DRBs during site visits have been of great value in preventing disputes. In principle a DB member may offer advice to both parties on any matter relevant to the Contract but the parties must both request it (see Clause 4(k) of the GCDBA). The agreement of the other DB members must also be obtained although it is not clear whether the agreement is required in relation to the act of giving the advice or the actual advice given.

Involvement of lawyers

Whether it is appropriate for lawyers to be DAB/DRB members or even participate in board proceedings has been a matter of some controversy. The DRB Manual adopts a flexible approach, advising that the overriding requirement is that the member meets stated criteria and that there is no good reason to reject a lawyer who meets them. Harmon [2002] carried out an empirical study into this issue, via a questionnaire survey of 63 participants at the 2001 annual meeting of the DRB Foundation. Of 50 questionnaires returned, 47 contained useful information on the issue of involvement of lawyers. That study confirmed anecdotal evidence that most non-lawyers would prefer lawyers not to be involved as DRB members or advocates at DRB hearings. However, there have been reports of very effective DRBs with lawyers as members [Matyas *et al.* 1996].

The adjudication cases reviewed indicate that use of lawyers and claims consultants is typical in UK adjudication. Their services include: drafting of communications between the parties leading up to the crystallization of disputes, drafting of referral notices, preparation of submissions, representation in the adjudication proceedings and representation in enforcement proceedings. The feature of adjudication that encourages such involvement of lawyers is the fact that the decision is easily enforceable, and this also applies to the DB technique. With the more challenging legal framework applicable to a DB in an international context much greater involvement of lawyers may be expected. The procedure for the DB under the Red Book allows the DB to vet representative of the parties. However, it doubted whether such power can be exercised to keep out lawyers without raising concerns about the requirements of natural justice.

From the similarity between the two techniques alone, at least the same degree of involvement of lawyers is to be expected. However there are features and issues specific to the DB technique that will make much greater involvement inevitable. Parties to DB proceedings are likely to be in dispute over much larger sums. As the board decision is admissible in any subsequent arbitration proceedings, parties will make extra effort to avoid unfavourable findings by the board. Furthermore, it can be concluded from the analysis of the legal framework applicable to enforcement of a DB decision that, on the question of access to a court and the appropriate enforcement method, there is a multiplicity of not only subsidiary questions but also legal systems according to which such questions are to be answered. This multiplicity creates a minefield of conflict of laws that cannot be navigated in commercial safety without considerable legal expertise.

Availability of potential DB members

In the global construction market there is a need for a large pool of potential DB members. The President of FIDIC maintains a list of persons qualified to act in this capacity, but at the time of writing there were only 26 members. Lists are likely to be developed by other organizations. Considering the novelty of the DB technique, possession of the necessary skills and attributes has to be a challenge although skills developed in other capacities such as arbitrator, adjudicator, claims consultant and specialist academic may be transferable to DB membership.

The problem of a sufficiently large pool of potential DB members for projects in developing economies is even more challenging. There is need for more legal knowledge than has been necessary for being a UK-style adjudicator or member of a US-style DRB. DB members must behave with appropriate cultural sensitivity. Civil engineering curricula of universities in developing countries are heavily biased towards science and technology at the expense of business management and law, resulting in a lack of basic knowledge of the drivers of construction disputes. There are therefore serious questions of appropriate curriculum development to supply graduates with basic understanding of the construction business environment and the principles of contract and dispute resolution. There are also issues of nationality and of language.

Governments are the main source of work for local contractors. This virtual monopoly creates an imbalance of power that makes local contractors extremely reluctant to pursue disputes. While foreign contractors have ready access to high levels of relevant expertise in their home countries, the opportunities for local engineers to develop direct experience of dispute resolution have been limited. Clearly, the need for appropriate curriculum development is urgent.

Running cost of the board

The capacity of developing countries to supply local candidates for DB membership is very low. All the indications are that members of DBs will be the elite of engineers, construction lawyers and dispute resolution practitioners from the developed countries. Routine site visits will require at least business class travel and board and lodging in international hotel chains that cost considerably more in developing countries than in developed countries. There is an absence of empirical data on of this item of cost. This limitation puts obstacles against making appropriate allowances for it in employers' budgets and contractors' tenders. However, likely fee levels of DB members provide an insight into the order of magnitude of the cost. The average daily fee is likely to be in the region of US$2,000, judging by hourly charging rates of construction lawyers in major European cities. Moreover, FIDIC [1996] and the World Bank [1995] originally recommended that, where the remuneration of DB member was not agreed, the fee of arbitrators under the regulations of the International Centre for Settlement of Investment Disputes would be used, which is currently US$3,000 per day.

Cost of deciding disputes

Commenting on the DB procedures in the Supplement to the fourth edition of the old Red Book, Seppala [1997] wrote that DB decisions are likely to result in no further proceedings. Thus, great effort is made in preparations for proceedings and submissions to a DB, perhaps as involved as those for arbitration. Lawyers and claims consultants are likely be retained on both sides. If natural justice and procedural fairness are to be respected by DBs, their procedural skills are likely to be tested to the limit, particularly where the DB members are not lawyers. This would also result in DB members spending more time reading submissions and preparing their decisions.

The potency of the binding effect of DB decisions as an influence on procedural complexity is borne out by experience of UK-style adjudication. In *CIB Properties Limited v. Birse Construction* [2004] EWHC 2365, which was brought to enforce the decision of an adjudicator, the judge commented with dismay on the large scale of the costs incurred in the dispute by both parties. The FIDIC DB is required to make a decision within 84 days after reference of the dispute. If the DB takes only a quarter of this time the cost would still be considerable. There is also lack of empirical data on numbers of disputes referred to DBs and the time taken to decide them. Such data would provide the parties with strong incentive to avoid formal disputes that are referred to the DB.

CONCLUSIONS

US-style DRBs have been very successful in avoidance and cost-effective resolution of construction industry disputes. Costs of this procedure have been reported to be in the region of 0.1- 0.3% of total project costs. This success has resulted in its adoption on some major projects outside the US but often with the innovation that the DB makes a decision rather than a non-binding recommendation. The DB process is likely to be more expensive for three main reasons: (i) the DB determines not only liability but also quantum; (ii) the fact that the solution of the DB is in the form of an enforceable decision is likely make the DB procedure far more formal and time-consuming than the US-style DRB procedure; (iii) the international context imposes upon the DB process a minefield of conflict of laws that cannot be navigated in commercial safety without high level legal knowledge.

By comparing the DB technique with established DRB and adjudication practices, this paper has identified likely features of decision-making DB practice in developing countries. These include a more complex legal framework, shortage of appropriately trained candidates for DB membership, domination of approved lists of approved potential DB members by elite of lawyers and engineers from the developed world, involvement of international lawyers and claims consultants, and need for more travel and boarding and lodging in hotels. These features are likely to make the DB environment a different animal altogether from that of the US-style DRB.

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The Practice of Subcontractor Appraisal in the Construction Industry of Hong Kong

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Abstract
Subcontracting is a mechanism used by contractors to redistribute their risks to an organization at the next tier along the supply chain. It is found that most construction projects worldwide have a large extent of subcontracted works, leaving the main contractors with a relatively small proportion of construction works along with other essential documentation, financial, managerial and supervision duties. As the subcontracting practice is so popular while the performance of subcontractors is major factor contributing to the project success, the industry is beginning to establish whether there is a solution to enhance subcontractor performance, and the monitoring of subcontractor performance is considered as possible way to eliminate incapable subcontractors. Until now, the industry is lacking of a standardized mechanism for measuring subcontractor performance. Although some contracting organizations have their own in-house subcontractor performance appraisal procedures, many studies have pointed to a general dissatisfaction in the performance of subcontractors and the practices of subcontracting. With this concern, interviews were conducted with the main contractors and subcontractors in Hong Kong. The purpose is to determine whether a generic procedure for subcontractor performance appraisal can be derived so as to develop a common standard to monitor the performance of subcontractors and to uplift the quality standard of construction works eventually.

Keywords
Subcontracting practice, appraisal system, project performance.

INTRODUCTION

Subcontractor is a team of specialized labors commissioned by the main contractor to accomplish a specific task in a construction project (Gray, 1989). Through subcontracting, contractors could fulfill the construction tasks at a reduced cost, better quality standard and more flexible organization structure (Fellows *et al*, 2002; Ng and Chung, 2005). Seeing the benefits of subcontracting, a significant amount of the construction activities are sublet to specialist traders in the industry. In the United Kingdom, the subcontracted work could be as much as 90% of the total project value (Nobbs, 1993). Russell and McGowan (1984) claimed that up to 95% of the total value was entrusted to subcontractors in Canada. The trend was similar in Asian countries like Japan (Reeves, 2002) and Singapore (Woon and Ofori, 2000). In Hong Kong, the average direct labor percentage

of projects was as low as 1%, and none of the projects had a direct labor content exceeding 7.5% of the total project value (Lai, 2000).
The system of subcontracting worked well in Hong Kong in the past when the construction community was comparatively compact, and many contracting firms enjoyed an intimate relationship with their subcontractors. Mutual trust and respect was a propelling force to ensure the assigned tasks were completed satisfactorily. Yet, as project complexity and price competition increases, contracting firms are tempted to transfer a greater proportion of risks to parties at the lower stream along the supply chain. Relying heavily upon the main contractors for survival, subcontractors have to accept time, cost and quality risks being transfer to them (Hinze, 1994).

Nonetheless with a relatively easy entry to the industry (Hegazy and Ersahin, 2001), some subcontractors may not have sufficient capabilities to undertake the required works satisfactorily (Kumaraswamy and Mathews, 2000). The employment of non-performing subcontractors may lead to adverse impacts, which might eventually result in project failure. The overall performance of the construction industry may be affected if the performance of subcontractors cannot keep up.

The general dissatisfaction with the practices of subcontracting has instigated a series of studies aiming at assuring the performance of subcontractors (e.g. Hsieh, 1998; Sozen and Kucuk, 1999). A recent industry report in Hong Kong recommends devising a mechanism to monitor subcontractor performance so as to provide a feedback channel to the contractors (Tang, 2001). However, in the absence of an agreed framework for appraising subcontractor performance, many construction projects still suffer from inferior quality, delays and over-budgeting.

The aim of this paper is to capitalize on the experience of current practice so as to identify a framework for appraising subcontractor performance. The paper begins by examining the subcontractor performance appraisal models around the globe. The procedures of subcontractor performance appraisal in Hong Kong are unveiled through a series of interviews. Comments for improving the existing practice of subcontractor performance appraisal are summarized in this paper.

DEVELOPMENT OF SUBCONTRACTOR APPRAISAL

An extensive literature review confirms that only few subcontractor performance assessment models operate in the industry worldwide. Examples of these include the US governmental departments located at South Carolina, the Department of Administration in the State of Wisconsin, Los Alamos National Laboratory, Fermi National Accelerator Laboratory, etc. Those assessment models are generally based on a series of performance indicators, such as schedule, quality, cost, safety, relationship, communication and documentation to measure the overall work performance. In the UK, there is a Quality Mark initiative for builders in the domestic repair, maintenance and improvement sector. Under this scheme, consumers can identify reputable builders who have demonstrated to independent assessors that they possess the skills and competence to complete work to a high quality standard.

In Singapore, the performance of subcontractor is assessed and fed back to a registration system known as the Singapore List of Trade Subcontractors (SLOTS) Registry. This system is administered by the Singapore Contractors Association Limited (SCAL) – an official representative of the construction industry in Singapore to serve the procurement needs of government departments, statutory bodies, public and private sector organizations. Subcontractors seeking registration should satisfy the requirements set out by SCAL which include their company's status, personnel resources, financial capability, track record and performance.

In Hong Kong, except for the model being adopted by the Hong Kong Housing Authority for assessing piling subcontractors, there is no other bespoken system for measuring subcontractor performance. Despite that, there are several systems developed by various organizations to evaluate the performance of main contractors, and these models are based on various performance indicators like workmanship, progress, resources control, health & safety, environmental protection, organization, general obligations, industry awareness, attendance to emergency, attitude to claims, relationship and communication to assess the performance.

To improve the quality of subcontractor performance appraisal, a reporting system for the construction managers to control over subcontractors was developed (Mendel, 1985). Besides, a computer-based system for controlling subcontracted work was introduced by Russell (1984). Albino (1998) developed a subcontractor rating model using neural network approach so as to support management decisions. More recently, a factor-based model was proposed by Wang (2005) for subcontractor management. In the manufacturing industry, Balakrishnan (1997) developed a simple system for evaluating subcontractor performance.

Despite the various research studies and practice, the construction industry is still lacking a rational procedure and a set of criteria for assessing subcontractor performance. Hence it is necessary to collect sufficient information from the industry in order to establish a suitable mechanism for subcontractor performance appraisal.

RESEARCH METHOD

A series of semi-structured interviews were conducted to unveil the detailed procedures and to solicit any guidelines being developed by contracting firms in appraising the performance of subcontractors. As each interview was only scheduled for an hour, it was considered necessary to restrict the number of questions to around 15. An interview protocol was developed to drive the interviewing process. The questions are broadly divided into three sections. The first section focuses on the background of the respondent's organization, e.g. the type and size of projects in which their company are specialized in; the proportion of works to be sublet; and the existence of a specific list of subcontractors. The second section is related to their perception on the importance of subcontractor performance. Questions on whether they will base on one's performance for selecting subcontractors; the importance of subcontractor's performance in a project; the importance of monitoring subcontractor's performance; and the purposes of subcontractor appraisal (e.g. reward or penalty) were asked. The details of subcontractor appraisal system are the focus of the third section in the interview protocol, and questions like whether a subcontractor appraisal system exists in their company; the criteria adopted for appraise subcontractor; and suggestions for improving the subcontractor appraisal practice were included. Further questions were asked throughout the interview process to clarify points and capture more details where necessary.

Profile of Interviewees

It was considered necessary to interview experts of both the main contractors and subcontractors to collect practical comments from these two key stakeholders, as there might be possibilities that the views of the main contractor may differ from the subcontractor. As a result, 10 experts of different background were selected and invited to participate in the interview process. These experts include 3 contractors, a large scale subcontractor and 6 subcontractors. To preserve the confidentiality of the interviewees as well as for easy reference, the 3 contractors are abbreviated as MC1, MC2, MC3; the large-scaled subcontractor as LSC; while the subcontractors as SC1 to SC6 respectively.

MC1 is a project manager with over 20 years of experiences and he is employed by a large scale main contractor. He is managing several large civil infrastructure projects. According to MC1, most of the works are sublet to subcontractors selected from its in-house subcontractor list. MC2 is an engineer with more than 15 years of practical experiences. He is looking after several building construction and maintenance projects. Their organization is highly relying upon subcontractors, with the sublet proportion of more than 90% for each project. He believes that an effective appraisal system is essential to maintain the overall performance of projects. MC3 is a qualified quantity surveyor with more than 20 years of experiences. He is working in a joint venture railway construction project.

LSC is an experienced quantity surveyor. As told, more than 85% of the works are sublet to sub-subcontractors from its in-house subcontractor list. As satisfying the documentation requirements have filled up most of their human resources, so companies of MC1, MC2, MC3 and LSC are adopting a very high subletting proportion in their projects. SC1 to SC6 are engineers and quantity surveyors working for subcontractors. These subcontractors are actually carrying out the construction works with only a small proportion of specialize items being sublet to specialist traders at the further tiers.

SUBCONTRACTOR APPRAISAL SYSTEM

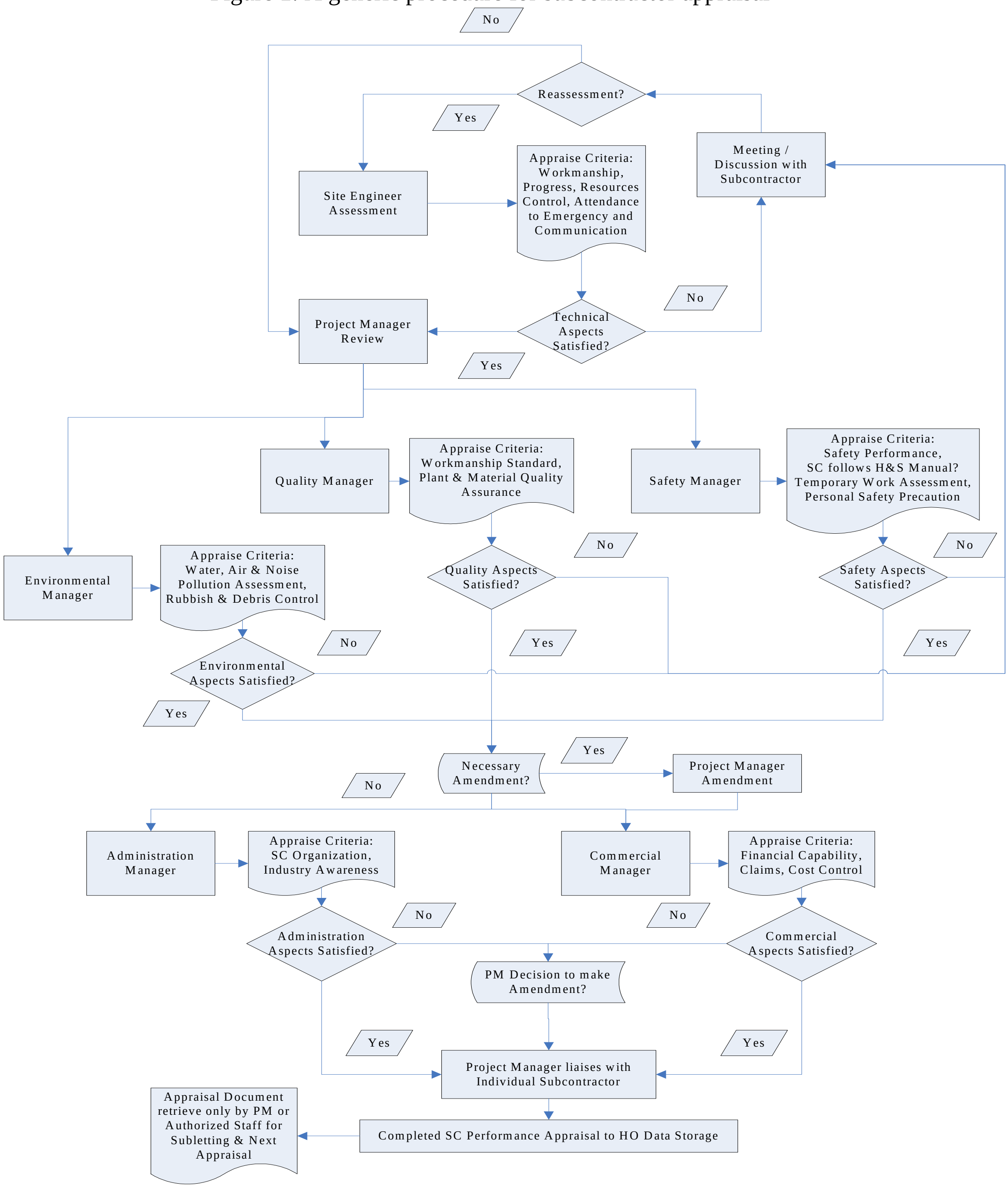
Having discussed with the main contractors and large scale subcontractor, it is encouraging to note that all have in-house procedures for measuring the performance of subcontractors. Consequently, the procedures were captured and reviewed. From that, a generic mechanism as shown in Figure 1 is derived from the systems being used by the interviewees.

The initial appraisal is usually conducted by the site engineer on the technical aspects. Relevant records related to the work done are then forwarded to the project manager for reviewing. The project manager then discusses with the safety manager on the health and safety issues so as to ensure the subcontractor is adhering to the requirements of the health and safety manual. Besides, the project manager would liaise with the quality manager and environmental manager to establish the standard of workmanship and the environmental awareness of the subcontractor. The project manager then makes adjustment to the appraisal if necessary.

Non-technical assessment will be carried out after the technical review. The administrator of the main contractor will examine the subcontractor’s industry awareness and its organization structure. On the other hand, the commercial manager would focus on the financial capability, claims and cost controlling matters of the subcontractors. Should the subcontractor have any financial problems, there might be chance of delay or suspension of the project, hence commercial matter is included in the subcontractor performance appraisal. Again necessary amendments will be made if required.

In order to maintain the fairness and preciseness of subcontractor performance appraisal, the overall assessment will be conveyed to individual subcontractor to determine if the result of appraisal is agreeable with them. Should no further amendment be needed, the completed appraisal result is archived in the head office database. The appraisal document would be made available to the project manager or other authorized staff for reference at time of another subletting exercise.

Figure 1: A generic procedure for subcontractor appraisal



Through the interviews, the criteria being used by each interviewee in assessing the performance of subcontractor are identified. As shown in Table 1, there are a dozen of criteria for which the main contractors would use for measuring subcontractor performance. The most popular ones include the workmanship, progress, health and safety, relationship and communication. Criteria of least awareness are the industry awareness and general obligation.

Table 1: Criteria for assessing subcontractor performance

Criteria	***MC1***	***MC2***	***MC3***	***LSC***	***SC1***	***SC2***	***SC3***	***SC4***	***SC5***	***SC6***
Workmanship	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Progress	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Resources control	yes		yes	yes	yes	yes		yes		
Health and safety	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Environmental protection	yes	yes	yes		yes			yes	yes	
Organization	yes			yes	yes		yes	yes	yes	yes
General obligations			yes				yes			yes
Industry awareness	yes									
Attendance to emergency	yes	yes	yes	yes		yes		yes		
Attitude to claims		yes		yes		yes			yes	
Relationship	yes	yes	yes		yes	yes	yes	yes	yes	yes
Communication	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

DISCUSSIONS

While the industry is placing an unprecedented emphasis on project performance, especially in relation to subcontractor performance, contractors inevitably encounter a great challenge in controlling their subcontractors. As almost 90% of the works are sublet to subcontractors, MC1 and MC2 believed a better monitoring of subcontractor performance is critical to the success of a construction project. Although some major subcontractors are now more prepared to take up the challenge of accepting a greater responsibility and risks associated with a project, certain naive ones still believe a good relationship with the main contractors alone could result in more business opportunity irrespective of what they produce.

It is good to learn that the main contractors now count on the appraisal information in selecting subcontractors for the next project (MC1, MC2, MC3 and LSC). They believed that the appraised results could serve as a penalty/reward mechanism to determine the future subletting opportunities of a subcontractor. In contrast, SC1 to SC6 believe that any subcontractor performance appraisal model is nothing more than fulfilling another documentation requirement under the quality management systems. All interviewees agreed that if more education and training on the importance of subcontractor performance to the overall success of the construction industry as well as the effective of subcontractor registration scheme, the performance standard of subcontractor could be guaranteed.

CONCLUSION

The practice of subcontracting in Hong Kong and abroad has been reviewed in this paper. As the industry has no standardized measure on appraising subcontractor performance, a literature review on the appraisal system worldwide has been conducted for reference. An interview survey among the contractors and subcontractors in the local industry has also been carried out. Based on the collected information, a typical subcontractor performance appraisal procedure is detailed in this paper. It is hoping that the industry is more concerned about the importance of monitoring subcontractor performance and hence devise an agreeable appraisal framework in the near future.

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Identifying the Factors that Influence the Use of Construction Partnering as a Procurement Strategy

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Abstract
The use of construction partnering as a procurement strategy has been inconsistent across construction industries globally. An incongruity exists between the strong advocacy of the use of partnering in the construction literature on the one hand, and the lack of actual adoption in reality by construction firms on the other. This paper argues that a main reason why there is this gap between research and practice is that there has been insufficient systematic studies by academics of the critical factors that underpin the selection of construction partnering which construction firms continually take into consideration. This paper reports the results of an empirical study which looks at how much these factors influence construction partnering under different industry characteristics. The results demonstrate that construction firms are far more discriminating in their choice of procurement strategy than what the literature would appear to suggest, and therefore, construction partnering should not be viewed as a one-size-fits-all means of improving project performance. This paper highlights the use of construction partnering is likely is contingent upon a set of industry factors that affect firms. Suggestions for future research to expand on the current study are offered.

Keywords
Construction partnering; procurement strategy; procurement selection; project performance; institutional factors

INTRODUCTION

Construction partnering is still popularly regarded as "the most significant development to date as a means of improving project performance" (Wood and Ellis, 2005, p.317). The steady stream of literature highlighting the potential benefits of construction partnering is widely accepted as an endorsement of its use as a choice procurement method in the construction industry (Bennett and Jayes, 1995; Black et al, 2001; Egan, 1998; Chan et al, 2003; Cheung et al, 2004). However, despite the continued popularity of construction partnering, no apparent industry trend exists to show that it is now the dominant choice of procurement method. The once valid argument that the absence of the widespread use of partnering is due to negative perception and attitudes among practitioners could no longer be substantiated because recent studies have found that attitudes towards partnering are becoming more and more positive (Wood and Ellis, 2005). Thus, other pertinent reasons exist which account for the discrepancy between the supposed tangible benefits that partnering brings and the lack of its adoption in reality.

This paper argues that one of the reasons for the patchiness of the adoption of partnering in the industry stems from the fact that construction firms do not appear to all jump on the partnering bandwagon despite its potential benefits. The commonly used term 'potential benefits' found in the literature would seem to suggest that in order to achieve the associated benefits, partnering must be contingent upon certain factors that make it an obvious choice of procurement method for construction firms in the first place. Therefore, the appropriate question here is not whether partnering is a more superior procurement method. Assuming that it is, given the positive endorsement that it receives, the question is why the majority of construction firms are still not using partnering to replace other traditional procurement methods? Following from this, the next question is what are the determinants predicting the likelihood that construction firms will adopt partnering? There are compelling reasons for asking these questions because if what is being preached by academics is not being practiced by the industry there is a need to understand (i) why does the gap exist and (ii) how can it possibly be bridged so that the rigour and applicability of the research and practice nexus can be strengthened further.

This paper reports the preliminary research findings that shed some light on the above questions and suggest ways in which this line of inquiry could be further developed to validate the results so far obtained.

Using institutional frameworks to explain partnering arrangement

Construction partnering as defined by Construction Industry Institute (1991) consists of "…a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximising the effectiveness of each participants' resources". In this regard, it is no different to any other types of inter-organizational alliances which "operate in a relational context of environmental interconnectedness" such that "an organization's survival and performance often depend critically upon the linkages to other organizations…." (Oliver, 1990 p.241). To this end, several theoretical perspectives exist to explain and predict the establishment, development, process, and outcomes of various forms of inter-organizational relationships. While transaction cost and resource dependency theories have been used in the past to explain construction organizational phenomena, one germane theory which has so far been neglected in the construction management literature is the institutional theory (DiMaggio and Powell, 1983).

A rich body of organizational and strategy literature exists to explain how and why institutional forces are important factors that contribute to the creation of different inter-organizational structures and alliances (e.g. Scott, 1987, 1998; Scott and Meyer, 1994; Zucker 1987). Institutional forces that arise from specific regulatory institutions (e.g. laws, regulations) and, normative and social norms (e.g. professional conformity, industry and societal expectations) will to a certain degree influence business decisions and organizational actions. In other words, the contexts in which business decisions are made are affected by pressures of firms seeking social conformity, and compliance with rules, regulations and norms which, in turn dictate what are regarded as desirable or legitimate business endeavours. The compliance with norms and regulations is deemed important because firms that conform "are rewarded….through increased legitimacy, resources, and survival capabilities" (Scott, 1987 p.498).

In addition, institutional theory suggests that because firms seek legitimacy, new organizational arrangements emerge as a result of firms attempting to achieve a fit with their institutional environments such that "firms within the same population facing the same set of environmental constraints will tend to be isomorphic to one another and to their environment…" (Dacin, 1997 p.48). Thus, when the same institutional pressures continue to exist over time, firms will become more homogeneous in what they do (DiMaggio and Powell, 1983) and as a result, a dominant organizational arrangement or 'proto-institution' (Lawrence et al, 2002) is likely to occur. Extending this argument to the construction industry, it can be argued that partnering arrangement has yet to achieve the status of 'proto-institution' where its practices, rules and technologies become so entrenched such that firms are compelled not to choose other practices, rules and technologies which are likely to make them less competitive.

METHODOLOGY

Using trade association and chamber of commerce directories, a questionnaire survey was administered to a population sample of 2602 foreign and local firms in Hong Kong which was framed from different sectors of the construction industry. The sample was believed to represent all construction firms operating in Hong Kong for which contact details, including the name of the most senior executive, were available. After two mailings, a total of 526 responses were obtained. A total of 270 firms were related to the construction contracting industry; 110 were construction consulting firms of one type or another, a further 101 firms belonged to the construction manufacturer and supplier industry; 15 firms were construction developers. Three hypotheses were developed to firstly test the relative importance of institutional factors and economic (financial) factors in predicting the use of partnering by construction firms, and secondly to test to what extent the use of partnering is influenced by firm perception of strong partnering norms within the industry. The variables used in the study were those that measure the (i) level of partnering use, (ii) perception of norms and expectations for partnering, (iii) firm competitiveness and profitability due to partnering use. Control variables such as size and age of firms were included to control for possibly confounding firm demographic effects, which may have an impact on firm's likelihood to use.

DISCUSSION OF RESULTS

This paper forms part of a larger research project that is currently underway to study partnering practice and the detailed empirical study based on the 526 data sets to examine the role that institutional factors play in the creation of partnering arrangement is reported elsewhere. This paper highlights some of the key findings obtained so far and discusses the implications they have for future research in partnering practice.

In support of the research hypotheses, the findings have clearly shown that partnering use is much more heavily influenced by industry norms and expectations for partnering than by the sole financial benefits that are associated with its use.

This is in stark contrast to the widely held view that firms are able to benefit financially from using partnering and, hence the assumption that such benefits alone would necessarily predict the use of partnering, the findings have shown that none of the financial incentives in terms of increased profitability, increased competitiveness or increasing the likelihood of firms winning contracts and securing business deals has any significant impact on partnering use at all.

However, the findings suggest that firms with a perception that partnering norms and expectations exist strongly in the industry are motivated to adopt partnering as conforming to such institutional pressures would add greater legitimacy and credibility to what they do. By complying with institutionally salient norms, firms view their choice of using partnering as rational because the added legitimacy might result in improved firm profitability through increased resource acquisition and reallocation. Therefore, the extent to which partnering is deemed profitable seems to be dependent upon how institutionally entrenched the practice of partnering is in the construction industry generally - the more embedded the practice is, the more likely firms will be inclined to its use.

Hence, the question of why there has been no visible pattern of firms using partnering across the construction industry can perhaps be pinned to the lack of systemic, overriding institutional pressures that drive its use. Without such pressures, it can be argued that firms view partnering as just one of the range of procurement methods that are available to firms and the decision to use partnering or any other methods will then rest more squarely on economic and market factors. Because the benefits, or more precisely, the economic and management advantages that firms could gain from using partnering is still debatable and difficult to measure, there is no *a priori* reason to expect firms to favour its use over other procurement methods other than the fact that there is obvious institutional norms that propel firms to use it.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Despite the strong advocacy of partnering use and of the purported benefits that it brings, it seems ironic that its implementation has remained at best, at a modest rate across construction industries. Past studies suggesting that the construction industry operates on a very competitively cost driven environment have helped to partially explain the reason for the lack of incentive for firms to use partnering (Bresnan and Marshall, 2000; Wood and Ellis, 2005). However, examining the issue from a totally different perspective, the results of this study show that institutional norms for partnering is an important contributing factor determining when firms are likely to use partnering. This has significant implications on the way research on partnering should be undertaken in the future. Rather than focusing on the purely economic determinants, studies should consider using institutional factors to explain and predict partnering formation. As far as this study is concerned, institutional forces far outweigh the importance of economic forces in determining partnering occurrence. Firms are inclined to use partnering not so much because they see it as a superior procurement method that brings increased firm profitability or competitiveness *per se* but rather because they see that there is an advantage in the face of strong industry norms and pressures to use it. Hence, future studies could usefully focus on how specific institutional pressures (i.e. regulations, policies, rules) determine the occurrence of partnering and to what extent. It appears from this study that the lack of strong institutional partnering norms in the industry largely explains why the implementation of partnering has remained patchy. One possible research avenue that stems from this would be to explore differences in the level of institutional pressures that construction industries in different countries have in relation to partnering practice and determine how this may in turn affect the level of partnering use. Perhaps this will then inform practitioners about where to divert their resources that will bring about the most sustained economic performance. These new lines of inquiries will shed much needed light on what actually determines partnering occurrence and why – a timely endeavour given the history of partnering research has been predominantly focused on economic factors.

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Investment Analysis and Valuation in the Office Buildings Market: Back to Basics

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Abstract
The quality analysis of investments in OFFICE BUILDINGS FOR LEASING (EEL), as well as the valuation of these assets, should be treated using suitable analytical models, especially with regard to the analysis horizon and the set of variables present in the long term scenarios. Analytical models represent behavior simulation structures for evaluating an investment's capability to generate revenue and measurements derived from the model, due to their link with behavioral definition scenarios, are not suitable for working with deterministic scenarios. It is necessary to consider scenarios which EEL´s behavior fluctuate between boundaries. When investment decisions are taken in market environments in which REITs already are highly significant, this refers to investing in securities, whose income is derived from the EEL portfolio. These securities have reasonable liquidity such that the investors tend to evaluate the investment's quality based on the preceding short term, projecting mirrored scenarios of these conditions for the future, short term. The procedure is only valid in this case, because, on investing directly in property (private REITs) or deciding on a property investment (public REITs management) effects caused by fluctuations in market behavior which impact flows of available revenue should be evaluated over 20-year cycles. In a long term investment, over short cycles, the investment's quality becomes dependent on the investment's alienation value, which is a much more open variable than the behavior scenario. Evidence from the São Paulo market, using a PROTOTYPE EEL, allows us to show why analyses should be undertaken over 20-year cycles and why it is necessary to work within bounded scenarios, abandoning the idea of scenarios with deterministic behaviors, even when these take into account the possible occurrence of real estate cycles.

Keywords
Office Buildings, investment analysis, valuation.

ASSUMPTIONS

Generally, real estate investment decisions tend to be made on weak foundations, mainly because investors assume that the investment's natural protection resides in the asset's physical existence, in its low rate of depreciation and on evidence that transaction prices do not tend to alter sharply in

short cycles. Investments in office buildings for leasing are the most expressive representatives of this line of investments.
In developed markets, in which the EEL property is represented by widely dispersed investment instruments (equity REITs) with reasonable liquidity, these investments are analyzed using short and medium term horizons, because the [return x value] ratio is the most significant expression for comparing with other business opportunities and for pricing the asset. This ratio remains the main indicator of an investment's quality because the accepted argument is that, using security instruments as vehicles in their competitive market, the investments tend to have prices which fluctuate slightly, because they tend to maintain steady revenue flows.
If we consider macro-economic effects, which may affect the competitiveness of a market segment, the intended homogeneity of revenue flows over short cycles can be an advantage when interest rates tend to fall, or a disadvantage, in the opposite case. This is because leasing revenue flows do not have the same elasticity as the capital market, as they remain steady during contract cycles and may only be altered, case by case, between cycles, depending on how movement in market interest rates affects the market segment's attractiveness.
This causes dissociation between the relative quality of investment in real estate (EEL) and other assets in the market, without the existence of efficient hedge mechanisms against this asymmetry. Large investment portfolios, sheltered under REITs, even when there are rigid cycles in each leasing agreement, can hedge the investment, because the universe of properties in the portfolio contributes to re-balancing the dissociations due to the non-coincidence of individual cycles for each leasing agreement.
When the investment strategy is focused on real estate property, as is the case in private REITs in the U.S. economy (Pagliari, Scherer and Monopoli, 2005), or in economies such as the Brazilian (Rocha Lima and Tavares, 2004), in which the market is predominantly still ruled by physical fixed asset purchases, investing signifies purchasing dissociation risks for which no hedge is possible.
For this text we use these evidences: [i] – the more developed markets, in which investments are made using securities backed by large portfolios and not directly by properties, tend to analyze the quality of the investment by their short (or medium) term profitability; [ii] – the more incipient markets, in the sense that real estate property is the object of investment and the investor is directly linked to leasing agreements, should have more sophisticated means of evaluating the investments, than merely relating the rentals practiced on the market with the price of the assets, to infer the static profitability and based on this, make an investment decision; [iii] - however, considering that the investment portfolios in the developed markets can only be constituted by purchasing the EEL assets, one at a time, each investment should undergo an analysis by the portfolio's administration similar to that carried out in incipient markets.

SYSTEMS OF ANALYSIS

Considering that invest in EEL trough REIT structures has, apparently, the same pattern that invest in any type of security fund, the investigations and valuation procedures seen in the majority of studies, articles and analysis reports are supported by behavior scenarios based on the past performance, on a macro-economic point of view.
I disagree with these procedures, stressing that EEL business merits a return to the origins, in analyzing investments, going back to basics, emphasizing the formation of qualified analytical systems, under penalty of, from time to time, consolidate in steel and concrete the errors of decisions biased by an understanding that the future necessarily reflects the present or past performance.
Thus, qualified systems should be able to work with speculation on investments' performance,

using suitable quality models, processing: [i] - reference scenarios, defined in planning, to recognize the quality configuration expected for the investment, in a 20 years operational cycle ; [ii] - stressed scenarios, defined in planning, to recognize the most conservative boundaries for the investment's quality; [iii] - pursuing the objective to calculate an appropriate set of indicators, capable of illustrating the investment's quality.
Analytical systems have quality the more clearly they are able to show risks, through exploring reference and stressed scenarios. In the case of EELs, in particular, noticeable aspects are the arbitrage of occupancy rates and the price of leases, variables which should not be explored using deterministic scenarios, but sets of scenarios which produce laboratory samples to measure indicators.

THE INVESTMENT CYCLE ON A DEVELOPMENT

The analysis of an EEL investment should respect the doctrinal assumptions recommended for real estate commercial development, which begin with the indication of an operating cycle, followed by the exhaustion period.
The 20-year operating cycle, together with the collection of funds to set up the asset rejuvenate reserve, which when reinvested provide the means of supporting the development 's capacity to maintain its competitiveness in the market, maintaining a stable insertion factor, is a defined premise for the analysis. Also the routine of imposing a further 20-year exhaustion period, to establish the development's market value at the end of the operating cycle, is also known. The investor's strategy, as regards maintaining his position in the EEL, should not be confused with these two parameters.
Whatever the size of the portfolio which contains one EEL, two analytical routines should be followed: [i] – the investment should be evaluated in isolation, applying the complete operating cycle, to measure indicators which are, according to the choice of scenario at the time of analysis, intrinsic quality characteristics of the EEL, because they are measured taking into account the life of the investment and, [ii] – the investment should be evaluated in accordance with the investor's assumptions, with respect to his strategy of retaining the investment's position.
The shorter the period the investor chooses to maintain his investment, in relation to the operating cycle horizon, the more the quality of the investment will be referred to the evolution of the EEL's market value. As the arbitrage of alienation value is more vulnerable than the arbitrage of revenue flow, the earlier the goal of withdrawing from the investment, the more speculative it will be.
As in the developed markets a significant share of the EEL investment funds are held in investment securities, tradable even daily, one understands that there is a tendency to work with short analysis cycles. However, for markets where the investment are still focused on the product (the EEL) and for portfolio managers who trade EELs rather than securities, the investment's quality evaluation should necessarily be based on 20-year cycles.
Short term scenarios, when used to analyze EEL investments, are suitable for measuring revenue but not for rates of return or valuation. To measure the rate of return, the withdrawal value assumed from the investment position intensely affects the rate's level the shorter is the analysis cycle. Using a PROTOTYPE reference for the city of São Paulo, for a 5 years investment cycle, the withdrawal value supports 65% of the investment at the expected rate of return. The true withdrawal value, which will effectively be practiced, not the one calculated in the investment moment, will be determined at the end of this 5-year cycle by the scenario of expected revenue generation from then forward. At this point, the next cycle (year 6 to year 10) will be considered for valuation of the EEL, and so on. Using the PROTOTYPE, at the end of 10 years, 40% of the investment is protected by the withdrawal value at the rate of return, while the balance (60%) is

protected by the revenue flow which took place over these 10 years. At the end of 15 years, 23% of the investment will be protected by the withdrawal value and, at the end of 20 years, 13%, which is still a significant amount.
In this PROTOTYPE, at the end of the 20 years, a 9.84% rate is granted by the revenue flow and the expected rate of return, 2 points higher (11.84%), is only guaranteed if the EEL is sold at the value defined at the beginning of the 20-year cycle.
As an investment in EEL can be sustained in a competitive form for many cycles beyond 20 years, maintaining the investment, the effect of the value of the property is diluted over time. Retaining 30 years, the alienation value will have supported 4% of the investment and at 40 years, a little more than 1%.

THE STRUCTURE OF INVESTMENT-RETURN FLOW AND MEASUREMENTS WHICH RELATE THE INVESTMENT IN A DEVELOPMENT TO THE EXPECTED AVAILABLE REVENUE FLOW

An analysis of the quality of an investment in an EEL requires the development to be broken down into two successive businesses;
[i] – the first corresponds to the investment in implementation, until the EEL is ready to operate and takes place in the implementation cycle. In this cycle there is a pronounced investment risk and this operation's quality is associated with how much can be obtained as a sales price for the ready and operating development. The dealing of implementation will be attractive if the price (PRE-0) at which it is possible to sell is higher than the developer's exposure (EXP-0) at this point, calculated with an attractiveness rate that is also a market reference.
[ii] – on completion of the implementation cycle, for the developer who is building to operate, the value of his stock should be remunerated rather than the investment to produce the value. In this way, entering the operating cycle the investment should be considered as the EXP-0 value and this should be contrasted with the return flow. In the case where there is a purchase for exploitation, the investment will be PRE-0. As this text does not discuss quality in the implementation cycle, we always start the analysis with a sight investment at the beginning of the operating cycle.
Within the operating cycle, the flow of return on investment (EXP-0) is structured considering the following financial movements: the development collects the gross operating revenue (rent payments for EEL leases); the revenue resources are used to pay the operating, administration and expense accounts; from the balance, a reserve fund FRA (an asset regenerating fund) is set up; the resulting revenue flow balance is for the investor, within the concept of available (free) operating profit flow RODi.
The flow RODi, is added to the EEL value calculated for the end of the operating cycle, to comprise the investment's return flow, which will serve to measure the development's quality indicators.
EEL's value at the end of the operating cycle is calculated based on the following assumptions:
[i] – the value of the development at this stage is the price which would be paid by a risk-averse investor who invests funds at the sector's rate of attractiveness;
[ii] – this virtual investor will promote the recycling necessary for the asset to run through another 20-year cycle, an operating cycle for this second virtual investor and an exhaustion period for the original investor.
[iii] – the revenue flow in the exhaustion period will be in line with the EEL's same market insertion parameters
In this way, the value at the end of the operating cycle (VOI-20) considering a specific investment

for recycling (IR) respects the expression: $VOI20 = \frac{(Re\,x - IR)\cdot Rop \cdot (1+t)^{20}}{(IR - Re\,x) + Rop \cdot (1+t)^{20}}$,

where $Rop = \sum_{k=1}^{20} \frac{RODi_k}{(1+t)^k}$; $Re\,x = \sum_{k=21}^{40} \frac{RODi_k}{(1+t)^{k-20}}$; t = sector's rate of attractiveness

The investment IR is defined by evaluating the life of the different components in the building, and then estimating its replacement cost in year 20, the end of the operating cycle. In a quick analysis, VOI-20 = 70% Rex may be used, which represents a sufficiently conservative position, equivalent to recycling something in the order of 70 to 80% of the building.
The return flow for the investment (EXP-0) is represented by $\{ RODi \}_1^{20}$, added to VOI-20 at the end of the cycle. This flow is the measurement source of all the investment's quality indicators.
The most elementary indicator which is the rate of return (TR) expected over the 20-year operating cycle, will be that given by the expression $EXP0 = \frac{VOI20}{(1+TR)^{20}} + \sum_{k=1}^{20} \frac{RODi_k}{(1+TR)^k}$.

VALUATION

An investment in EEL will have its value calculated with the same routine as previously indicated, considering that the value is EXP-0 in the expression given above by replacing TR for the desired rate of return for the investment.

BEHAVIOR SCENARIOS

Behavior scenarios outline assumptions on the state of the variables which result in investment return flows for a 20-year operating cycle horizon.
The development's performance depends on systemic variables associated with operating costs and the EEL's insertion in the market.
The greatest vulnerability in EEls lies in market insertion, where variables are not susceptible to monitoring, as: [i] - competitive prices, because they are dispersed, [ii] – occupancy in the competitive segment, because it depends on the global relationship between supply and demand and the global level of economic activity; [iii] - rate of inflation, which provokes losses in revenue, as under prevailing market practices, the rental prices may only be adjusted in distinct cycle of at least one year.
An EEL investment is protected not by the stability of the property's value but by the EEL's performance in its competitive market environment. Fluctuations in occupancy tend to make the market reduce EEL valuations and this happens because of investors' tendency to consider long cycles as reflections of the short term. The consequence is that the perception of EEL's value in the market tends to vary in accordance with fluctuations, both up and down, in the capacity to generate revenue. This posture, which investors assume, is frequently copied by planners and consultants and explains what are conventionally called real estate cycles. Some researchers refer to these cycles as being of the nature of the market. I disagree, stating that cycles can occur, because in times of crisis, investors' conservative nature tends to draw behavior scenarios for the long term which reproduce present situations, and which when generalized, induce a market trend. With regard to the virtuous element of the circles – growth which ends in a flood of

uncontrolled offers, provoking crisis – these can occur as a response to the speculative frenzy present in real estate markets where the price practiced is confused with value. In general, during the virtuous cycle, the developers who build to sell, speculate on the investors more lenient attitude to risk, which leads them to purchase EELs on a false conclusion that high prices can be sustained over long cycles.

DETERMINISTIC SCENARIOS

There is no way of supporting the assumption that any market will have a stable behavior over long cycles. To the contrary, there is a great deal of evidence to support the statement that markets' behavior varies over long cycles. The real estate market fluctuates in behavior over long cycles, so that measuring quality indicators of an investment in an EEL should be based on forecasts of behavior fluctuations over 20 years. Behavior factors defined for 20 years represent an element of risk for the investment decision, because they can not be validated as reflections of the conjuncture in which they are designed, but should contain an accentuated speculative facet.

When the EEL behavior scenarios for analyzing the investment is designed the market works at a certain price level and the supply and demand relationships, measured indirectly by the occupancy rate shown by the market, serves as the point of departure for the 20-year scenario.

If it is probable that the market fluctuates within this horizon, what should be the basis for forecasting the behavior and what risk is associated with the decision based on the scenarios thus conceived?

Some scholars propose that the real estate market necessarily goes through cycles and even tried to determine the duration and interval of fluctuation in each cycle, using historical data, with the goal of designing behavior scenarios to validate investments. I envision the cycles in a different form. I do not consider that they are either characteristics of the market or that they have a deterministic cause. All markets are susceptible to speculation and the greater the delay in the effect of an unsuccessful play or the more hidden the effect of a successful one, the more difficult it is to educate the market to dampen the intensity of speculative movements. Cycles occur in any market, ultimately caused by greed for wealth and by a negative perception of risk.

Whatever scenario is designed it can only represent a 20-year trend, in the case where no macro-economic factor causes impact on the EEL market. Hence, there would be support for and confidence in a deterministic speculation for a shorter cycle than the 20 years required to make the analysis of the development's quality. This demands that building a scenario beyond the horizon in which one can detect the effects on the market (around 5 years), should be based on a foundation of speculations on the result of market reactions to the effects produced by investments within the shorter term horizon (the 5 years), apart from other macro-economic impacts, as the EEL market, in this sense, is always passive.

The evidence is that it is impossible to infer confidence in quality indicators in EEL investments produced with support from deterministic scenarios, because apart from the short cycles (around 5 years), what happens depends on the form in which the agents react to the state of the market at the formative moment of the investment decision. The scenarios for supporting the quality analysis of investments in EEL should have another formatting structure.

SCENARIOS SUPPORTED BY BOUNDARIES

Evidence of past behavior and an evaluation of the effects of the economy on the EEL segment, always allow three reference points to be drawn with a certain degree of confidence:

[i] - a conservative behavior boundary is one from which the investment becomes unattractive. In this way, recognizing the segment’s attractiveness standards, a boundary is found for the virtual behavior, measured in models, which corresponds to the configuration of an acceptable extreme rate of return. A market operating on this boundary should provide a disincentive for investments, so that should demand appear later, the behavior will escape from this conservative boundary;
[ii] - an aggressive behavior boundary is one which represents a quality standard for the investment above the risks presented by the segment. Using suitable benchmarks, a quality reference above the segment’s attractiveness can be established as boundary. The market will never stabilize in an aggressive position, because this would represent a paradox, but in topical situations, during a certain interval of time, the remuneration of investments in EELs can be favored;
[iii] - the reference behavior configuration is represented by an intermediate position between boundaries, associated with perceived market attractiveness.
Hence, the scenario for the 20-year operating cycle, supported by boundaries thus designed, will be any one, in which, each year, the average behavior of the EEL will be in a defined position between the boundaries. This reasoning does not conclude for determined indicators, but indicators in bands. If EXP-0 or the acquisition price PRE-0 are defined, then the rate of return and other quality indicators of the investment, such as simple payback, duration and the recovery and investment return curves will be measured or drawn in bands, with a certain degree of confidence. If the investor’s rate of attractiveness for the investment is defined, then the valuation will lead to a band of values that are valid for making the investment with, naturally, the value most protected from risk being the floor of the band.

THE SIGNIFICANCE OF USING SCENARIOS SUPPORTED BY BOUNDARIES

To show the influence of the scenarios’ structure on the analysis of an EEL investment, we use the PROTOTYPE references for the market in the city of São Paulo, validated for July-2005. We draw three behavior 20-year scenarios, as registered in Table 1: [i] - extremely conservative, deterministic, with an insertion into the market in five years; [ii] - even more conservative, deterministic, showing rhythmic 10-year cycles of increasing and falling occupancy rates, and [iii] - with boundaries for occupancy rates and for the leasing values.

Table 1. Occupancy rate and rental rate.

OCCUPANCY RATE

	SCENARIO [i]				
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5 & REGIMEN
market average	65%	80%	85%	87%	90%
PROTOTYPE	65%	80%	95%	100%	100%

	SCENARIO [ii]										
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10	YEAR 11
market average	**65%**	80%	85%	87%	90%	85%	81%	77%	73%	69%	**65%**
PROTOTYPE	**65%**	80%	95%	100%	100%	94%	90%	85%	81%	76%	**72%**

	SCENARIO [iii]					
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	BOUNDARIES IN REGIMEN
market average	65%	80%	85%	87%	90%	
PROTOTYPE	65%	80%	95%	100%	100%	+ 0 points - 18 points

RENTAL RATE (R$ / sqm GLA)

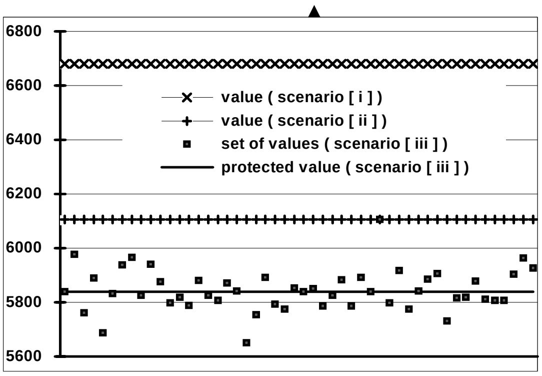
	SCENARIOS [i] and [ii]				
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5 & REGIMEN
market average	52	55	65	68	70
PROTOTYPE	44	55	65	68	70

	SCENARIO [iii]					
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	BOUNDARIES IN REGIMEN
market average	52	55	65	68	70	
PROTOTYPE	44	55	65	68	70	+ 4% - 12%

Internal Rate of Return. Using the July-2005 market costs to build the PROTOTYPE and a 22% wacc rate above inflation, for investments made in the implementation, we register an EXP-0 of R$ 5,106 / sqm GLA. Considering EXP-0 as investment, at the beginning of the 20-year operating cycle: [i] – the behavior of the EEL according to the deterministic scenario-[i] leads to a 13.08 % annual rate of return, effective above inflation; [ii] – according to scenario-[ii], also deterministic, 12.31%, and [iii] – working with a suitable sample of values, constructed based on the reference of fluctuations between the scenario-[iii]'s boundaries, with 90% degree of confidence, the rate of return will be situated between 11.58% and 11.60%. It should be noted that the cyclic market behavior scenario is as deterministic as scenario-[i]. The scenario-[iii] with boundaries infers much greater confidence from the information, because the only deterministic assumption is that the frontiers will not be surpassed, such that when its elasticity represents comfortable information for the investor, its use support the decision to invest with greater safety.

Valuation. Defining the rate of attractiveness at 10% per year, as the mark at which a risk-averse investor would invest in the PROTOTYPE, the value of the investment opportunity according to the scenario adopted for calculate, will be: R$ 6,680/sqm GLA with scenario-[i]'s behavior, R$ 6,106 with scenario-[ii] and R$ 5,840 with scenario-[iii].

Graphic 2. Set of Values (R$ / sqm GLA)



The value calculated under scenario-[iii] represents the floor of the confidence interval, for 90% degree of confidence. It is measured via a sample of values, each one derived from a particular behavior scenario in which, over the 20-year operating cycle, the rate of occupancy and the rent value fluctuate randomly between the scenario's boundaries. Even considering cycles, which for some researchers could represent an advance in the criterion for formatting scenarios, the defined value represents less protection. The pure deterministic scenario necessarily represents the highest value and consequently the lowest implicit protection for the investor. Graphic 2 illustrates the different values of the sample, the boundaries and also the values associated with the deterministic scenarios.

CONCLUSION

Methods for valuation and analysis of the quality of an investment in EEL should be supported by models that are capable of exploring scenario configurations without deterministic roots. The simplification of adopting deterministic scenarios can lead to high risk investments, hidden behind the image of real estate deals being implicitly protected by the underlying assets. A long-lived underlying physical asset does not mean stable underlying physical asset value. The value of an EEL is a function of its ability to generate revenue and how this is exploited over further 20-year cycles, the scenario for sustaining this should be defined considering aggressive and conservative behavior positions, so that the defined value already includes a risk protection component.
When the analysis required refers to the quality of an investment at a certain price, the indicators should also be supported by defined scenarios within boundaries, so that the indicators are presented in intervals and not at a specific point.

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Knowledge Management in the construction sector: A case study

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Abstract

This paper describes the background and methodology developed and employed to define a Knowledge Management Strategy (KMS) for a construction company. Two central objectives structure this Case Study:

1. To identify categories of important information generated and shared between internal employees and external stakeholders,
2. To improve knowledge and communication management by formulating an appropriate and targeted KMS and developing and implementing an ICT system.

Keywords

Knowledge management, information management.

INTRODUCTION

The need for change and continuous improvement in the construction industry has resulted in various initiatives, which are aimed at improving the construction process. These initiatives are primarily targeted at reducing fragmentation, and have included (Carrillo P, et al, 2000): (a) the development of alternative procurement strategies to clarify and improve the communication structure between different participants in the construction process (BPF, 1983); (b) the use of computer technology to integrate the construction process through the electronic sharing of data/information in both directions at the design-construction interface (Howard et al. 1989; Evbuomwan and Anumba, 1996); (c) the adoption of a wide range of concepts, tools and techniques to enhance collaboration, and improve efficiency and quality (Bennett and Jayes, 1998); and (d) the development of improved components, materials and construction methods, including standardisation and pre-assembly (Egan, 1998).

Within the construction industry, it is increasingly being acknowledged that KM can bring about the much needed innovation and improved business performance the industry requires (Webb, 1998; Egbu et al. 1999). Failure to capture and transfer knowledge generated within one project, which is usually buried in unread reports and arcane filing systems, or lost because people move on, leads to wasted activity and impaired project performance.

This paper is based on the CRAFT project 'Environment and Logistics integrated in Construction Project Management' CRAF-1999-70679. The main objective was to develop an integrated, organisational, construction knowledge management system, and a model for implementation in small and medium sized enterprises (SME). The system, based on ICT-platforms, was adapted to the competence and operational level in the SMEs and was based upon quality management principals in the construction industry. In addition to developing a system, the project included the developing and testing of special procedures and critical tasks in: Building refurbishment focusing on environmental aspects (SMEs with environmental focus) and integration and collaboration between technical installations companies (SMEs with logistic focus).

This paper focuses on the information technology (IT) and contextual issues involved in formulating an appropriate knowledge management strategy for construction organizations.

The methodology carried out to define a Knowledge Management System (KMS) for SMEs of the construction sector and implement it in a restoration company (Natur System) is defined and described.

The definition and implementation of a KMS for the Case Study allowed the author to conclude that ICT tools and training for a new conceptual idea on KM and IM can benefit the whole management of the company and improve its organizational and functional management.

KNOWLEDGE MANAGEMENT

Knowledge management can be defined as the identification, optimization and active management of intellectual assets to create value, increase productivity, and gain and sustain competitive advantage (Webb, 1998). It involves the capture, consolidation, dissemination and reuse of knowledge within an organisation. The formulation of a knowledge management strategy involves an examination of a number of interrelated concepts and factors (Kamara et al. 2000).

METHODOLOGY

The current literature on KM and the surveys carried out in the company allowed the authors to formulate a method for achieving their research objectives:

1. A thorough and critical review of the literature on KM for construction projects was conducted.

2. A qualitative and quantitative survey was carried out.

3. A methodology to formulate a KMS was defined.

4. An integrated, organizational ICT System was developed.

5. The KMS and the ICT System were adapted and evaluated and general conclusions and results were drawn.

Literature review on KM for construction projects

First, we mapped practical tradition of work in Spain related to refurbishment and reconstruction. Concretely, we studied general conditions of the construction sector in Spain and established comparisons between the whole construction sector and the refurbishment and reconstruction sub sector. To map the practical tradition of work, we exposed relevant laws and regulations of the specific sub sector (The Building Act, 158/1997 Decree, to regulate the Building Book of the existing buildings and to create the Programme for the revision of the state of conservation of buildings destined to housing).

Qualitative and quantitative survey

We prepare a Qualitative/Quantitative Study in different companies by developing a questionnaire. We also carried out and exhaust mapping of all the companies working process.

The case study is based on Natur System S.L. which is a construction firm whose main business is, amongst other, facade restoration and rehabilitation. Natur System S.L. is a medium sized company with a huge experience in this specialized area of the construction sector. Actually it is one of the three most solvent enterprises dealing with facade restoration in the city of Barcelona. It must be said that this company has got the ISO 9002 certification in one of its building processes. This company gives work to 25 workmen of its own, including 15 painters and 10 bricklayers, and about 20 more people, working with administrative and directive tasks. Another 100 external people are contracted, including external workmen, transporters, external commercial agents, etc. Natur System S.L. serves, mainly, to three kinds of customers:

1. Horizontal property (for instance, a neighbour’s community).

2. Vertical property (for instance, the single owner of a flat).

3. Customers with specific requirements (Hotels, Church…).

Definition of a methodology to formulate a KMS

In relation to the Improvement Methodology we also analyze the critic points of each SME. The improvement methodology with its progress plan can be synthesized as follows:

Firstly, to work out an improvement program which is based on meetings, analysis of the current practices of the activities of the company, mapping of environmental problems and choosing the project to test.

Secondly, the objective was to initiate improvements by introducing and discussing them and develop some procedures to improve these activities.

Then, the analysis of the improved practices on related activities was done. Revise procedures and methods and correct them.

Finally the use of the quality system was integrated and supervised.

The last step of the improvement methodology was to integrate and supervise the use of the quality system. Once the procedures were consolidated in each company working processes, they should be included in the Quality System of the company.

Development of a Knowledge Management System

With the aim of developing and implementing the KM software, we systematized each company's needs in relation to the software tool for knowledge and information. During this process we have exchanged information, suggestions and proposals of improvements of the tool with Holte, the company in charged of developing it. Holte sent all the partners a Questionnaire of the Use of HolteProsjekt Knowledge Management System so as to get the main features and necessities of each company. After having available the first draft of the Holteprosjekt tool, each company started to implement and adapt it to their necessities.

Natur System described their own aspects to filter the information: Quality, Environment, Safety & Health, Advance, Changes, Contracts, Costs, Project, Risks and Programming.

They also defined their own types of documents: Minute, Project, Procedures, Contract, Forms, Incidences, Check list and Reports.

Adaptation and evaluation of the Knowledge Management System

We tested the software in a specific project and we extracted some conclusions that will be shown as example for transferring the results and the use of ICT-CPM system to similar enterprises/construction projects in Europe. The test was done in the restoration of the main façade of a building in Barcelona, 359 Balmes street.

CASE STUDY

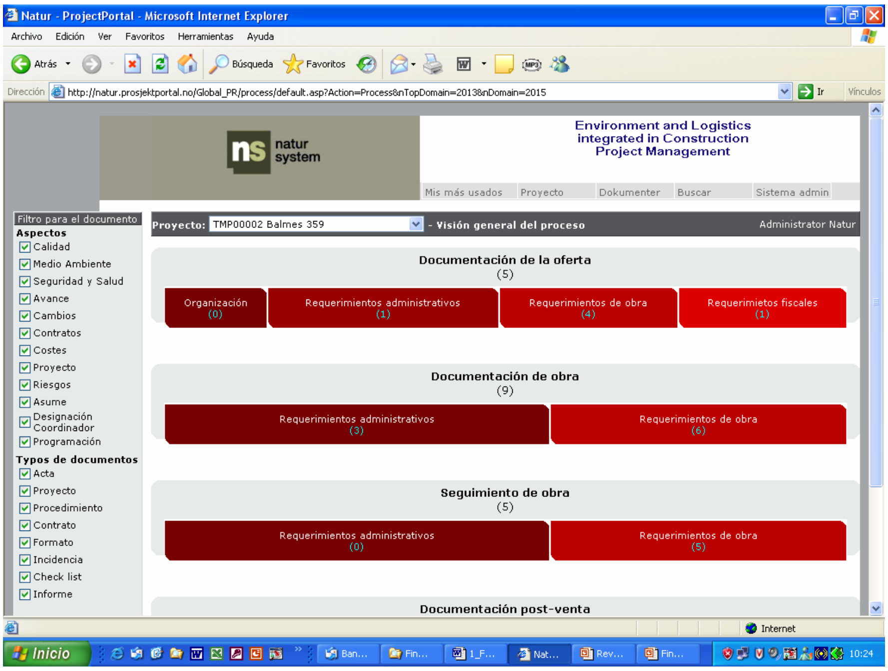
The main result from Natur System was the introduction and use of an ICT tool for the knowledge management of the company.

The web-based Knowledge Management System is an integrated, organisational construction project management system. Its main objective is to increase the efficiency of the small and medium sized enterprises (SME) in the construction/building sector.

Some screens of the HolteProsjekt tool (adapted to NS and translated into Spanish) are shown below:

Figure 1 shows the visualization screen of the process defined for the test project (Balmes 359). On the left hand side there are the aspects and type of documents defined by Natur System.

Fig 1. The visualization of the process defined for the test project



The following screen (Fig 2) shows the connections from the processes to the project types with the aim to generate automatically the organization structure of whatever project.

Fig 2. Connections from the processes to the project types

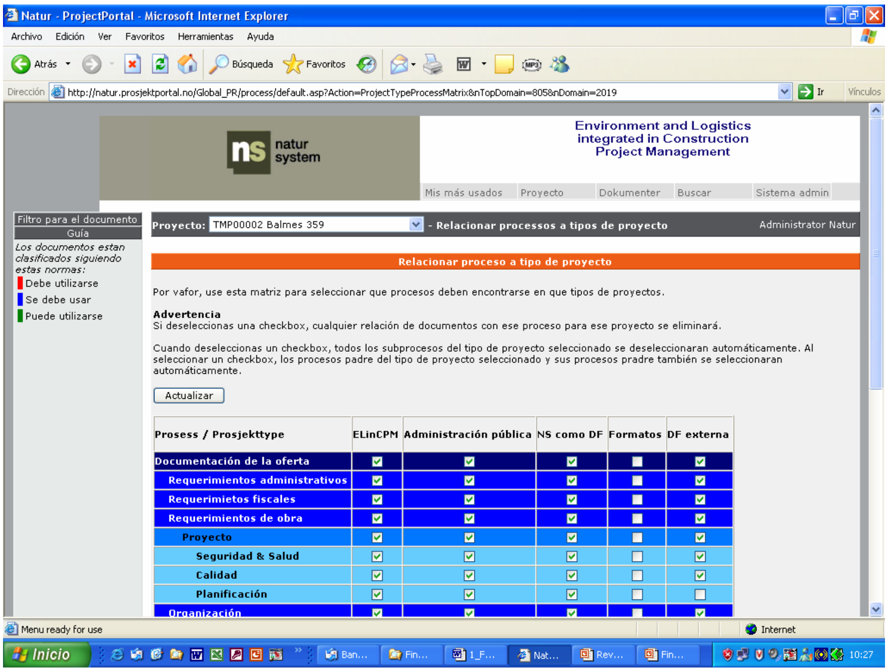
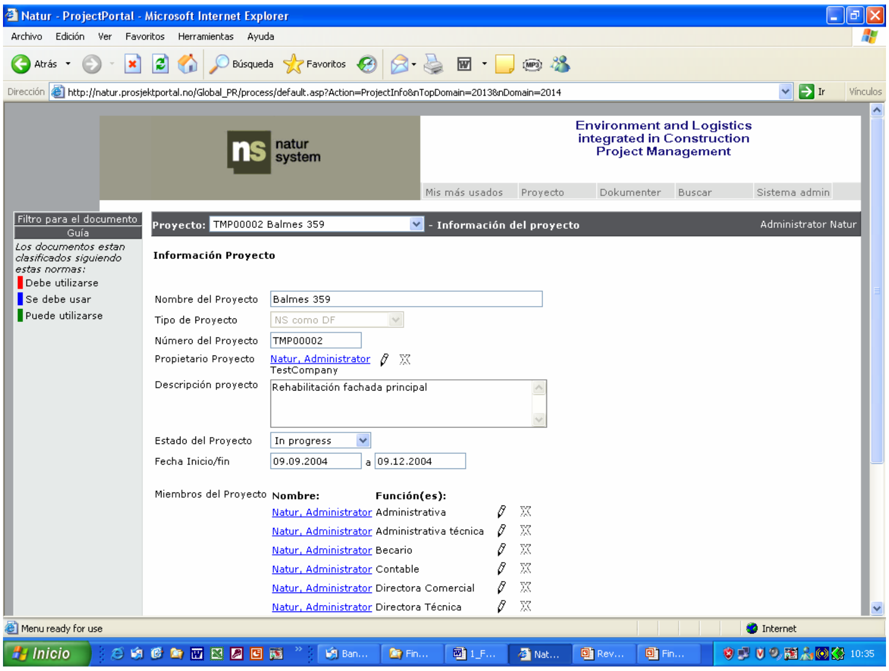


Figure 3 shows the first screen of the system where all the information of each project is required.

Fig 3. Main screen to visualize all the information of the project



RESULTS

This web based KM System has been tested and adapted to the competence and operational level in Natur System and the main conclusions and results from this pilot test can be broken down into:

Improvement of the document management

The introduction of the web-based Knowledge Management System allows an important improvement of the document management in NS, organizing as much the project information as the business' information. The use of this tool improves the management of whatever information, allowing all the people from NS access the permitted information whenever they want and wherever they are (via Internet).

Improvement of internal processes

As a collaboration software tool, this tool enables the organization to centralize electronic documents, thus allowing users from a number of different organizations to work in a more collaborative fashion. The primary objective is to move away from traditional sequential paper-based systems, thereby breaking down barriers to communication.

New business benefits derived from the use of collaboration software include: a) Immediacy: send an electronic document to a website and it is immediately available for viewing; likewise, written feedback is available without delay, b) Community: the cost of forming project groups (and or groups of common interest) is reduced, c) Significantly: increased communication increases trust, which can lead to increased innovation, d) Connectivity: potential for interoperability with business applications provides near-term project based perspective, e) Transparency: alignment of business processes increases transparency as barriers to communication are removed; users' actions on the collaboration system are recorded for audit purposes. Collaborative systems reduce the amount of re-work by storing not just information but the knowledge that derived it.

Improvement of external processes

Collaboration software tools enable communication and centralization of documents, information and knowledge through a website. Therefore, using this web-based KM system, NS will be able to share the information they want with clients or other related companies who might need this information. In a near future, using this service will be a need rather than a possibility because of the market push.

Introduction to New Technologies to SMEs personnel

ICTs represent an authentic revolution, in terms of radical change of the current reality but the users are not traditional companies that must adapt their working processes to this new working model and they should adapt their necessities to the new competitive advantages that new technologies represent.
The integration of construction processes using IT offers considerable potential for construction firms. However, despite these promises, there are often significant implementation problems associated with the adoption of IT. The implementation process is essentially, multi-faceted and includes technical, business and organizational aspects. The most challenging objective was to introduce to all the personnel of NS to another method of working using New Technologies.

IMPACT

From the ICT tool point of view, Natur System tested the KM software by uploading not only the procedures of the project we are testing to http://natur.holteprosjekt.no but also other information of the project. The person in charge of a specific document is using the KM tool to store it and make it available to all the other people of the company (with the previous defined access rights). For the moment, Natur System employees are satisfied with the tool and find it a good solution for the internal document management of the company.

The KMS and the ICT System proposed in this Paper and evaluated positively by the company can be implemented in many other SMEs of the construction sector with the consequent improvement of the management of their internal and external KM and IM.

CONCLUSIONS

Collaboration software has shown to have tremendous potentials not only in adding value to the internal performance of an organization, but also to the whole supply chain and therefore to the client.

Moreover the success implementation of these tools not only requires a state of readiness within one organization, but also within all those involved in all the process. This makes the successful implementation of such tools difficult to be planned for and managed.
The teething problems and change in working culture and practices, which is initially required, very often deters the users. Achieving the kind of targets that are needed in today's environment requires major change in the organization, including practices, systems, processes and workflows. The right strategies and implementation plans have to be developed, communicated and brought to life.

It is much more difficult to successfully embrace collaboration tools for SMEs because of the different practices used in different organizations and the extra complexity dimension which is added by the type and level of incompatible computer systems used by these organizations.

The industry should work towards minimum common standards to facilitate the flow of information across the all the process. Such standards will add significant value up the chain by allowing exchanged information to be fully integrated with business processes.

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An Evaluation of Property Portfolio Diversification Strategies in Nigeria.

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Abstract

This paper identifies diversification strategies adopted in the Nigerian property market and evaluates the effectiveness of the strategies with a view to determining the benefits of each strategy to investors and also moves the profession in Nigeria forward towards meeting the global trends. This is against the background of greater unpredictability and volatility in the Nigeria property market and the increasing need for investors to diversify risk of their portfolios.

Questionnaires backed up with interviews, were administered on 28 institutional property investors in Lagos, Abuja and Port-Harcourt metropolitan areas. Pooled data on rental transactions and capital values for the period of 1998 – 2003 involving 76 properties were also collected from the investors. Data were analysed with the use of frequency distribution, relative importance index, Sharpe's Index and mean/standard deviation ratio.

The study's results showed that "property type" and "geographic naïve diversification" were the preferred strategies in the Nigerian property market and that these strategies did not give the best protection to investors' portfolios against the risk situation in the market. The results of the evaluation revealed that the best strategy would be to adopt efficient portfolio strategy and invest better proportions of a real estate portfolio in residential properties located in Lagos metropolitan area.

Keywords

Diversification strategies, efficient portfolio, emerging real estate market, naïve portfolio.

INTRODUCTION

The concern for better decision making in portfolio diversification has received a worldwide attention, especially in the developed countries. This is in realisation of the fact that investment scene (property investment inclusive) throughout the world is characterised by risk and uncertainty and ignoring them may bring peril. Arising from the need to address the problem of risk and uncertainty, the pattern of investment has changed substantially and investors have seen the safety aspect of diversification as risk may be reduced by a trade-off with return. In the like manner, the drive towards the integration of quantitative strategies, as developed under Modern Portfolio Theory (MPT), into property portfolio diversification and management has increased. In the United State, Britain and Hong Kong for example, studies such as Hadaway (1978), Miles and McCue (1982), Grissom et al (1987), Mueller (1993), Williams (1996), Cheng and Liang (2000), Brown et al (2000) and Viezer (2000), have evaluated and determined the benefits of various diversification strategies to their investors. These studies have shown that different diversification strategies come with different portfolio benefits. Therefore, the question of how best to allocate investment funds within real estate portfolio to achieve optimal return/risk is not ambiguous to investors in these countries.

In Nigeria and most of the other developing countries' emerging real estate markets however, little or nothing is known when related to property portfolio diversification strategies and the question of how best to diversify investment funds within real estate portfolio. Whereas, the markets in these countries are experiencing tremendous growth and structural changes and there is an emerging trend towards indirect ownership of property investment and an increasing need for investors to diversify through the selection of a combination of assets. It is thus necessary that a study of this nature be carried out to investigate the benefit of different 'within real estate' portfolio diversification options in an emerging property market like Nigeria.

The demand for this type of analysis is amplified by the need to respond to the challenges posed, to the country, by globalisation and technology advancement. In other words, there is an increasing need to move the Nigerian real estate portfolio management and diversification practice forward towards meeting the global trends and also protect investors' funds against the ravages of risk which has become prevalent in the Nigerian property market. It is also important that for the real estate profession in Nigeria (like most other developing nations) to stay relevant in the emerging global property market, the practice must keep abreast of and adjust to ever-changing trend in the profession. Otherwise, investors and the economy at large will continue to suffer hardship as a result of investment liquidation, while there is a danger that lies in the possibility of the investors being disenchanted and the profession rendered obsolete. Therefore, this study has recognized the need to examine diversification strategies being adopted in the Nigerian property market with a view to determining the benefits of each strategy to investors.

LITERATURE REVIEW

Few studies in the area of property portfolio management in Nigeria have recognized the fact that different allocation skills or diversification strategies of investors or managers could bring different portfolio performance [Olaleye (2000); Ajala (2001) and Olaleye and Aluko (2003)]. However, none of these studies had examined diversification strategies and evaluated the superiority of the strategies against one another. Though, Olaleye and Aluko (2003) evaluated managers diversification of real estate portfolio, they failed to look into other 'within real estate' diversification strategies.

In contrast, a substantial number of studies have focused on evaluating the effectiveness of portfolio diversification strategies especially in the U.S., Hong Kong and U.K. Some of the studies attempted to determine how effective is diversification of a portfolio as more properties are included [Cullen (1991); Brown (1997); Ziering and Mclctosh (1999); Lee and Bryne (2000) and Bryne and Lee (2001)]. Others concentrated on determining the superiority of diversification strategies in terms of their effectiveness. Examples can be found in Miles and McCue (1982), Hartzell, et at (1986), Grissom et al (1987), Mueller (1993), Cheng and Liang (2000), Brown et al (2000) and Viezer (2000). Most of these studies focused mainly on examining the efficiency of mean variance portfolio against a corresponding naïve portfolio. They also focused on property type and geographic/economic diversifications as they are judged by authors such as Grissom et al (1987), Pagliari et al (1995) and Cheng and Liang (2000) to be the most popular among investors. A few of these studies, such as, Miles and McCue (1982), Mueller and Laposa (1995), found evidence to suggest that property type diversification is superior to geographic diversification. Others support the fact that geographic diversification is superior to property type diversification while some others found that diversification across market and property type reduced unsystematic risk more than across just market or across just property type [Hartzell et al (1986) and Grissom et al (1987)]. Mueller (1993) and Brown et al (2000) found evidence to suggest that diversification within even more narrowly defined areas – intracity- could produce improved performance.

A major limitation of these studies is the fact that they missed regarding portfolio diversification in an emerging real estate market. In other words, while the studies have concentrated on examining the diversification strategies and their effectiveness or benefits in a developed real estate market, none has actually identified and evaluated diversification strategies in an emerging real estate market. Thus, the question of what diversification strategy gives the best benefits to investors in an emerging real estate market, like Nigeria, is still to be answered. This paper provides answer to this important question.

METHODOLOGY: DATA COLLECTION AND ANALYSIS

Questionnaires, backed up with interviews, were administered on 28 institutional property investors in Lagos, Abuja and Port-Harcourt metropolitan areas of the country. Pooled data on rental and capital value transactions for the period of 1998 – 2003 were also gathered from the investors. From these transaction data, average holding period returns and standard deviations were calculated for each of the properties. The total response for the property investors was 12 (43%), while the pooled data on rental and capital value transactions involved 76 properties comprising residential and commercial properties in the three locations considered.

The data on diversification strategies were analysed with the use of frequency distribution, mean and standard deviation measures. In evaluating diversification strategies, 13 different naïve diversification portfolios were developed for use as benchmark portfolios and their mean/standard deviation ratios as well as their Sharpe indices compared with that of the efficient portfolios constructed using constant correlation model. The calculations were based on the belief that investments are held long since the property market in Nigeria is yet to be fully integrated into the capital market operations and most investments are held long. The use of constant correlation model also allowed us to single out just six portfolios for testing against the naive portfolios and thus we do not have to test every single efficient portfolio, which of-course, is infinite in number. The six portfolios tested were based on +1, +0.5, +0.1, -0.1, -0.5 and –1 correlation coefficients between each pair of asset. See Elton and Gruber (1981) for detail descriptions of the procedures involved in this model.

RESULTS

The results of the analysis are presented in this section.

Diversification Strategies Adopted in the Nigerian Property Market:

As shown in Table 1, all of the institutional property investors adopted naïve diversification strategies in their practice. This therefore shows that naïve diversification strategy is the preferred strategy in the Nigerian property market. Two reasons can be suggested for this finding: (i) efficient portfolio (modern portfolio theory based) diversification strategies involved complex mathematics; (ii) investors generally are known to be reluctant of investing on the basis of trading and allocation system that they do not understand. In addition, the lack of time series data for explicit analysis involved in efficient portfolio diversification might have also influenced this finding.

Table 1: Diversification strategy adopted by real estate investors

Diversification strategy	Response Level	Percentage of response (%)
Naïve	12	100
MPT based	--	----
Both	--	---
None	---	--
No response	---	---
Total	12	100

Source: Field data analysis, 2004

Naïve Diversification Strategies Preferred

To identify the preferred or adopted naïve diversification strategies in the Nigerian property market, questions were asked that required the investors to rank, in order of frequency of usage, their methods of naïve diversification practice. These ratings range from mostly used, normally used, of less usage and not in use. Their responses are then given ranking of 3, 2, 1, and 0 for mostly used, normally used, of less usage and not in use respectively. The analysis of responses to these questions is by means of frequency counts, mean and standard deviation measures. Table 2 shows the details of responses.

Table 2. Naïve diversification strategies adopted by the investors

Diversification strategy	Mostly used	Normally used	Of less usage	Not in use	Mean	Standard deviation
Geographic/ economic	5(41.7)	6(50)	1(8.3)	---	2.333	0.651
Property type	6(50)	6(50)	---	---	2.500	0.522
Property/Geographic	4(33.3)	2(16.7)	6(50)	---	1.833	0.937
Managers diversification	--	2(16.7)	1(8.3)	9(75)	0.417	0.793
Timing diversification	---	2(16.7)	---	10(83.3)	0.333	0.779
Lease diversification	---	1(8.3)	1(8.3)	10(83.3)	0.250	0.622
Investment structure	---	1(8.3)	1(8.3)	10(83.3)	0.250	0.622
Investment vehicle	---	1(8.3)	1(8.3)	10(83.3)	0.250	0.622

Source: Field data analysis 2004
Note: the Figures in bracket are percentages

The analysis in Table 2 shows that property type and geographic/economic diversification strategies are the most preferred naïve diversification methods in the Nigerian property market. Using the mean and standard deviation of each strategy, property type diversification ranked first in the order of frequency of usage among the investors. It has the highest mean (2.500) and the lowest standard deviation (0.522), which also shows that the degree of consensus of opinion about the results, among the responding investors, was the highest. Geographic/economic diversification ranked second with a mean value of 2.333 and standard deviation of 0.651. The frequency distribution results show the same conclusion (see Table 2). Other methods, such as manager's diversification, timing diversification, e.t.c were not common in use. This finding confirms the superiority of the two diversification strategies over the others in terms of their level of usage by investors as theory led one to expect. The analysis that thus follows focuses on these two strategies.

Evaluation of the Efficiency of Diversification Strategies:

In evaluating property types and geographic/economic diversification strategies, 13 different naïve diversification portfolios were developed based on:

1. Diversification by metropolitan areas (wherein property purchase is not given consideration) and where investments were either in one location (3 portfolios) or 33.33% of investment value in one location (1 portfolio).
2. Diversification by property types wherein property purchases are considered. Here, the study considered (a) 50% allocation to each property type (residential and commercial property types were included by reason of data availability) in all the metropolitan areas (1 portfolio). (b) Investment in one property type in each of the three locations at a time (combination of three properties from the locations) (6 portfolios). (c) All investment to one property sector wherein location is not given consideration. (2 portfolios).

Table 3 presents the results of the average (mean) returns of the portfolios, their risks (as measured by their standard deviations), Sharpe indices and their mean/standard deviation ratios. The risk free rate (Treasury bill) for the period of measurement (1998 – 2003) averaged 12.54%.

Table 3: Returns and standard deviations, Sharpe indices and mean/standard deviation ratios of Naïve (benchmark) portfolios.

S/N	Strategies	Portfolio returns	Standard deviation	Sharpe indices	Mean/standard deviation ratios
1.	a. All investments to Lagos metropolitan area	10.100	0.347	- 7.037	29.107
	b. All investments to Abuja metropolitan area	16.693	0.570	7.286	29.286*
	c. All investments to Port-Harcourt metropolitan	21.573	0.896	10.081	24.077
2.	33.33% allocation to each of the locations	16.122	0.604	5.930	26.692
3.	50% allocation to each property type in the locations	16.122	0.604	5.930	26.692
4	Combination of investment in one property type in each of the three locations at a time.				
	a. Combination of residential property type in all locations	15.926	0.559	6.057	28.490
	b. Residential properties in Lagos and Abuja plus commercial in Port-Harcourt	16.311	0.655	5.757	24.902
	c. Residential properties in Lagos and Port-Harcourt plus commercial in Abuja	17.855	0.571	9.308	31.270*
	d. Commercial properties in Lagos plus residential in Abuja and Port-Harcourt	14.004	0.541	2.706	25.885
	e. Commercial properties in Lagos and Abuja plus residential in Port-Harcourt.	15.933	0.553	6.136	28.812
	f. Commercial properties in Lagos, Abuja and Port-Harcourt	16.318	0.649	5.821	25.143
5	a. All allocation to residential property type	15.926	0.559	6.057	28.490
	b. All allocation to commercial property type	16.318	0.649	5.821	25.143

Source: Field data analysis, 2004.
* Dominant portfolios in terms of mean/standard deviation ratio.

The results in Table 3 show that the portfolio returns and standard deviations range from 10.100 (0.347) to 21.573 (0.896) for metropolitan diversification portfolios (geographic diversification) and 14.004 (0.541) to 17.855 (0.655) for property types diversification portfolios. The range of return and risk (11.473, 0.549) tended to be higher for geographic/economic diversification portfolios than for property type diversification portfolios (3.851, 0.114). Although, geographic diversification produced higher return portfolio, the standard deviations of returns show that the chances that investors' actual returns would deviate from expectations are higher when compared with property type diversification portfolios. The result further shows that the diversification strategy of investing in one property type in a location at a time produced a better (dominant) portfolio in terms of mean/standard deviation ratio. This is the portfolio combining residential property in Lagos and Port-Harcourt and commercial property in Abuja. The strategy of investing all investment value in one (Abuja) location ranked second. The two strategies produced portfolios with 31.270 and 29.286

mean/standard deviation ratios respectively. These results therefore indicate that investors, in the Nigerian property market, may be better off, in terms of return/risk ratio, by choosing to diversify their investment portfolios using property type diversification strategies. Although, the strategy produces low returns when compared with geographic diversification strategy, it compensates these with lower risks so that property type strategy produces portfolios with higher return/risk ratios.

Diversification by Metropolitan Areas Using Constant Correlation Model:

The results of the geographic diversification portfolios using constant correlation model and based on correlation co-efficient of 1.0, 0.5, 0.1, -0.1, -0.5 and -1 are shown in Table 4 below. The results include the mean return, standard deviations, weights, mean/standard deviation ratios and Sharpe indices of the six efficient portfolios constructed.

Table 4: Diversification by metropolitan areas using constant correlation model (Efficient portfolios)

Portfolio correlation	Portfolio return	Standard deviation	Mean/standard deviation ratio	Sharpe indices	Percentage allocation (weights)		
					Lagos	Abuja	Port-Harcourt
+1.0	21.573	0.896	24.077	10.081	0.000	0.000	1.000
+0.5	19.846	0.781	25.411	9.355	0.000	0.354	0.646
+0.1	19.070	0.729	26.159	8.957	0.000	0.513	0.487
-0.1	18.904	0.718	26.329	8.864	0.000	0.547	0.453
-0.5	18.718	0.705	26.550	8.763	0.000	0.585	0.415*
-1.0	18.977	0.723	26.263	8.903	0.000	0.570	0.468

Source: Field data survey and analysis.

* Dominant portfolio in terms of mean/standard deviation ratio

Among these portfolios, the one based on correlation co-efficient of -0.5 produced dominant results (26.550) in terms of mean/standard deviation ratio but underperformed the dominant naïve portfolio (29.286) based on this strategy. However, in terms of Sharpe index, this portfolio, which happens to be the least performed of the efficient portfolios (8.763), outperformed all the naïve portfolios based on this strategy except the one that allocates all investment value to Port-Harcourt area only. In all, it is noted that, among the efficient portfolios, the range of results (return and risk) is less than those realized for naïve diversification strategies. Range of returns is 2.855 vs 11.473 for efficient and naive portfolios respectively, while range of risk is 0.191 vs 0.549 respectively for efficient and naïve portfolios. This result shows that while the use of geographic naïve diversification strategies may produce portfolio that could be found to be efficient than optimal (efficient) portfolio, there is much to be gained in terms of reducing the tracking error risk when constant correlation (efficient) portfolio strategies are used.

Diversification by Property Types (Constant Correlation Model)

In constructing property type efficient portfolios, the study considered the individual return and risk level of the properties considered (76 in all) spanning all the locations and sectors. The results of the mean return of portfolios, standard deviations, mean/standard deviation ratios, Sharpe indices as well as the weights of the portfolios constructed based on correlation co-efficient of 1.0, 0.5, 0.1, -0.1, -0.5 and -1.0 are shown in Tables 5 below.

Table 5: Property type Constant correlation portfolios by considering individual property return data

Portfolio correlation	Portfolio return	Std. Dev.	Mean/ Standard deviation ratio	Sharpe indices	Percentage allocation to each property										
					1	2	3	4	5	6	7	8	9	10	11
+1.0	36.900	0.530	69.623	45.962	1.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
+0.5	19.062	0.155	123.206	42.077	.155	.808	.037	.000	.000	.000	.000	.000	.000	.000	.000
+0.1	19.982	0.217	92.083	34.083	.092	.642	.048	.067	.010	.064	.006	.063	.004	.004	.000
-0.1	20.370	0.256	79.646	30.586	.072	.546	.044	.072	.012	.078	.009	.095	.008	.052	.013
-0.5	18.657	0.151	123.698	40.510	.109	.824	.067	.000	.000	.000	.000	.000	.000	.000	.000*
-1.0	17.478	0.115	151.996	42.939	.117	.883	.000	.000	.000	.000	.000	.000	.000	.000	.000

Source: Field data survey and analysis. *Dominant portfolio in terms of mean/standard deviation ratio

Note: 1 represents a commercial property in Abuja, 2 represents a residential property in Lagos, 3 represents a commercial property in Port-Harcourt, 4 represents a residential property in Port-Harcourt, 5 represents a residential property in Port-Harcourt, 6 represents a commercial property in Abuja, 7 represents a commercial property in Port-Harcourt, 8 represents a residential property in Lagos, 9 represents a commercial property in Port-Harcourt, 10 represents a residential property in Lagos, 11 represents a residential property in Abuja.

Although, the range of portfolio returns using this strategy is higher (19.422) than for other strategies, the results of the portfolios' standard deviations, mean/standard deviation ratios and Sharpe indices in Table 5 show that there is much more to be gained when this strategy is adopted. Apart from the fact that virtually all the efficient portfolios formed from this strategy greatly outperformed the corresponding naïve portfolios, they outperformed all other portfolios (both naïve and constant correlation portfolios) from other strategies (see Tables 3 and 4). This result therefore suggests that it might be better to diversify by property type considering individual property returns using efficient portfolio strategy (constant correlation model). This might be the result of the fact that this strategy produced portfolios that gave more opportunities for better spread of risks by investing some proportions of the portfolio value in more numbers of properties. One other thing deducible from Table 5 is that greater proportions of each of the portfolios were allocated to residential properties in Lagos. For example, the allocations to residential properties in Lagos add up to 0.808, 0.709, 0.693, 0.824 and 0.883 for portfolios based on constant correlation of +0.5, +0.1, -0.1, -0.5 and -1.0 respectively. This result suggests that much might be gained by investing greater proportions of a real estate portfolio in residential properties located in Lagos metropolitan area.

CONCLUDING REMARKS

The results of this study showed that investors combining real estate assets into portfolios will be better off when they adopt property type efficient (constant correlation) portfolio diversification strategy. However, for an investor whose main focus is increased portfolio return, such investor will achieve his aim, much better, when he adopts geographic/economic diversification strategy. Specifically, it is shown that the best portfolio to hold would have been in Lagos with high weights in residential property sector. In summary, the results revealed that ‘property type and geographic naïve diversification strategies’ that were given priority in the Nigerian property market did not give the best protection to investors’ portfolios against the risk situation in the market.

The implication of the above can be quite serious. There is a danger that lies in the possibility of the investors being disenchanted and the profession in Nigeria rendered obsolete and irrelevant in the emerging global real estate market. There is therefore the need for practitioners to adopt quantitative analysis in their portfolio diversification decisions. Meanwhile, in discussing these findings, a note must be made of the fact that active portfolio management practice rests on comprehensive data and information bases with careful maintenance and updating, without which a meaningful measurement and analysis of a portfolio is impossible. There is therefore the need for databases (which hitherto are lacking) at local, state and national levels to enhance the preparedness of the Nigerian investors to benefit from the emerging trends in portfolio diversification analysis.

Meanwhile, it should be noted that while the study’s results showed that efficient portfolio strategy outperformed most of the naïve strategies evaluated, the statistical significance of this result is not shown. Therefore, a further research can be undertaken to test the statistical significance of the results obtained in this study. Another possible area for further research would be to evaluate the effectiveness of diversification strategies based on ex-ante analysis of return/risk characteristics of real estate portfolios since this study was based on an ex-post analysis.

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Capacity and Capability Development in Indigenous Construction Firms trough Technology Transfer in Construction: A Malaysia Experience

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Abstract

Abundance of unskilled labor, lack funds and utilize inferior technology are among the well-known characteristics of construction in developing countries. The situation is further aggravated by the lack of overall relevant policies focusing on construction. The indigenous construction firms in developing countries are characterized by mostly small and the lack of capacity and capability, confidence, motivation, long term aspirations, etc. Many are still struggling without basic foundation on which construction firms' internal strength depends on The technology transfer has been one of the popular method for achieving the these objectives. It is expected that a substantial degree of technology would be transferred by foreign international contractors to indigenous contractors by the end of a contract period. However, the extent and quality of transfer varies with the parties involved. The variability in achieving a desired transformation objective is a major obstacle to the production of capable indigenous contractors. It is therefore, important to identify the factors affecting transformation performance; which include in this research, the internal characteristics of the receiving firms, the technology transfer program, and the type of technology. The respondents for this research were indigenous contractors with some past experience in technology transfer programs in construction projects in Malaysia. The findings of the research confirmed that the internal characteristics of firms, technology transfer program, type of technology and the transformation performance are significantly related.

Keywords

Capacity and capability, technology transfer, factors affecting transfer, indigenous construction firms, construction industry, developing countries, Malaysia.

INTRODUCTION

The capacity and the capability of the construction industry in many developing countries, as in any infant industry, are still substantially deficient. These weaknesses are well known and had been widely reported (World Bank, 1984; United Nation, 1984; Kirmani, 1988; Turin, 1973; Wells, 1986). Various efforts were carried out to overcome these problems, including the introduction of the technology transfer program (Abbott; 1985). In construction, the formation of joint-ventures between local and foreign contractors has been recommended by the World Bank (1981). This is supported by Carrillo (1993), the integration of local and foreign constructors in construction projects can facilitate the transfer of technology. Numerous studies have been carried out on technology transfer in fields other than construction (Wallender III (1979), Germidis (1977), Bradbury (1978), Campbell (1984), Marton (1986), OECD (1981), and many more). In construction, there are a few studies in technology transfer that had been carried out extensively. They are Drewer (1975), Abbot 1985), Mansfield (1992) Simkoko (1989), Carrillo (1993 and 1996), Ofori (1994).

In the process of the technology transfer in construction, it is expected that, at the end of the contract period, a substantial degree of technology has been imparted by foreign international contractors to indigenous contractors of host countries who will then be able to play a major role in undertaking similar projects in the future, both domestic and international There are numerous factors affecting the performance of the transformation over time. It is assumed that the rate of success varies and is unique for each program and this depends on various factors, which include the internal factors of the receiving companies, the environments of host countries, the technology transfer program, and the type of technology in question.

This paper investigates the impact of technology transfer on the capacity and capability development of the receiving construction companies with emphasis on factors affecting the transformation performance during the process of transfer of the required construction technology to the indigenous construction companies in Malaysia.

Research Objectives

The main objective of the research is to study the role and contribution of technology transfer in developing and upgrading the capability and the capacity of the indigenous construction companies in developing countries from the receiving end. Other specific objectives are as follows:

1. To establish relationships between the degree of transformation and the factors affecting transformation,
2. To establish relationships between the factors affecting transformation, and
3. To establish the strength of these relationships.

Research Methodology

A survey method was adopted where questionnaires were designed to obtain all the information needed for testing. 42 active Malaysian local contractors of various background and sizes and with experience in technology transfer were used as respondents in this study. Data collected was analysed with SPSS for Windows, a statistical package designed for social scientists. Since the numbers of respondents are small (n=42) and data are largely nominal and ordinal type, nonparametric statistical techniques were used. Thus, contingency table, chi-square test of association and Spearman's rank correlation are adopted in data analysis.

THE CONSTRUCTION INDUSTRY IN DEVELOPING COUNTRIES

The construction industry in developing countries shares many of the problems as are found in the developed countries. According to Edmond and Miles (1984) the structure in developing countries is an extreme version of its developed country. There is a small number of large companies, often foreign-owned, who carry out the majority of the work (Kirmani, 1988). The World Bank (1984), Edmond and Miles (1984), Rau (1983), Kirmani (1988), UCERG (1972), Chang (1987), Abbott (1985) and many more have listed abandon of weaknesses, the construction industry in the majority of developing countries must be, as Wells (1986) put it, by any definition, `inefficient', with low levels of productivity and high costs.

TECHNOLOGY TRANSFER

In construction, technology transfer involves individuals at various level of an organization such as top and middle management and operative levels (Al-Jalal, 1991). The formation of joint ventures between local and foreign contractors has been recommended by the World Bank (1981). The integration of local and foreign construction companies in construction projects can facilitate the transfer of construction technology (Carrillo, 1993).

Technology Transfer In Construction

According to Simkoko (1989), the technology transfer process in industrial projects differs somehow from construction projects, however both sectors undergo more or less similar phases in their realization. The evidence of similarity in life-cycles of the industrial and construction projects is seen in the following grouping of construction project phases: conceptualization (i.e. conception, feasibility studies and inception); implementation (design, engineering and construction); and operation or utilization (Bell and Hoffman, 1981). In the construction delivery process, the capacities and capabilities are provided concurrently in the sense that construction techniques are employed in the project execution, while the know-how and managerial skills, and experience act as necessary inputs on the construction techniques. Thus, integration of both the local and foreign technological and managerial capabilities in the project delivery process can facilitate the transfer of technological capabilities to the developing countries (Simkoko, 1989).

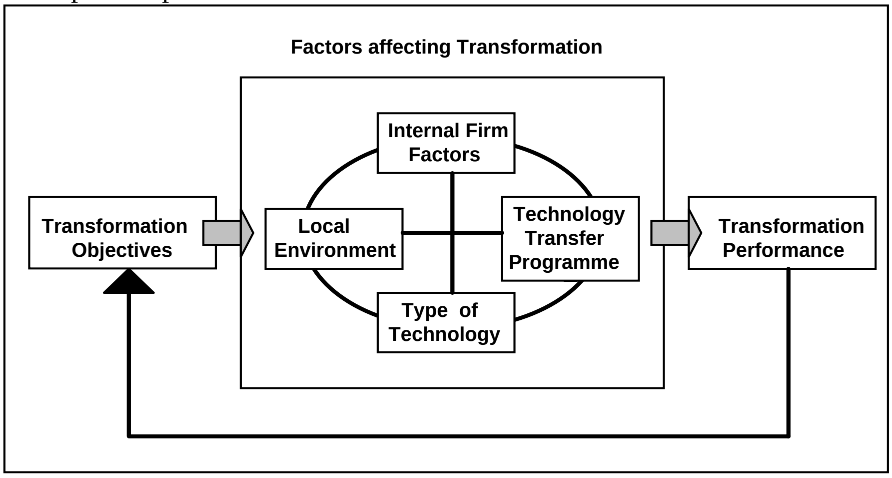
Factors Affecting Technology Transfer

Wallender lll (1979) has discussed extensively on factors affecting technology transfer in his study in various industries. However, the construction industry was not included in his study. According to Wallender lll (1979), the variety of factors that influence the ability of a firm to receive and utilise technology can be grouped into three categories; firstly, the internal characteristics of the firm; secondly is the external environment and thirdly is the process of consultation. A total of 31 factors were identified as having some effects on the ability of the firm to receive and exploit technology.

RESEARCH MODEL

In establishing a relevant research model, a pattern of relationships has to be established by relating all the relevant variables. Adopting suggestions forwarded by Wallender lll (1979), a model of transformation was established. The major variables affecting transformation can be identified as internal factors of the receiving companies, the program of technology transfer, and the type of technology (as shown in figure 1).

Figure1: The Input-Output Model of the Transformation Process



Factors Affecting Transformation

Factors affecting transformation are numerous. This research, however, has identified and considered 4 major factors to be studied. They can be categorised as: the internal factors of the receiving companies, the environmental factors of host countries, the program of technology transfer, and the type of technology (Bradbury and et. al., 1978; Wallender III, 1978; Simkoko, 1991; Collinson, 1992). This study does not include the aspect of environment as all respondents were from one country. It is reasonably acceptable to assume that the environmental factors are constant. The factors are as follows:

1. Receiving Firms - Internal Factors

Management and Organization

1. Management practices
2. Management style
3. Organizational structure

The Historical Factors

1. Stage of development
2. Technology acquisition history
3. Technology acquisition objectives

Resources Factors

1. Management resources
2. Technical resources
3. Financial resources

2. Type of Technology

Technology as knowledge:

1. General business
2. Industry specific
3. System specific
4. Company specific
5. On-going problem solving

3. Technology Transfer Programme

The mechanism used: direct

1. Mode of transfer
2. Training cost
3. Training duration
4. Management focus
5. Technical focus
6. Local company involvement
7. Transfer program

4. Technology Transfer Performance

1. Improved products
2. Improved process
3. Improved problem solving capability
4. Overall performance of technology transfer

The dependent variable - the Variability in Transformation

The variability of transformation in this case is actually companies' performance which can be measured in many forms. One of them is organizational effectiveness, described by organizational theorists in many different ways. It is difficult to identify which is an appropriate measure for this purpose. Steers (1980), Campbell (1983) and Schaan (1983) are among the many authors that discussed extensively on this matter.

The measurement adopted in this study includes financial (profitability), i.e., the change in profitability after their involvement in the technology transfer program; capacity, i.e., the change in the value of net assets after being involved in a technology transfer program and capability, i.e., the change in the stage of development in technology acquisition (Wallender III, 78) after involvement in a technology transfer programme.

RESEARCH HYPOTHESES

If one considers technology as a commodity that can be bought in the form of capital goods, which includes machinery and productive system and information, a very simplified mathematical model can be expressed to represent the argument (Bradbury, 1978; Simkoko, 1989) such as follows:

$Qt = f(C, L, T, t)$; where ; Qt is the production volume, C is the input of capital, L is the input of labour, T is the input of technology, and t is time.

Using the mathematical model of relationship suggested by Bradbury (1978) above, Simkoko (1989) has successfully carried out the test on his work which is related to factors impacting technology transfer in construction projects.

The question is:
Is transformation performance a function of internal factors of firms'? The environmental factors of host country? The technology transfer program? The type of technology? And technology transfer performance?

This has led to the formulation of the overall hypothesis of this research which is: ***when the technology transfer program and the type of technology involved are appropriate to the internal factors of firms, a better technology transfer performance can be achieved and this will induce a better transformation performance.***

The above hypothesis has generated five main hypotheses and they are as follows:

1. Transformation performance (TP) is a function of the internal factors of firms (IFF), the technology transfer program (TTP) and the type of technology involved (TT); in mathematical model, this hypothesis can be expressed as:
   TP ~ f (IFF, TTP, TT)..(1)
2. Technology transfer program is a function of the internal factors of firm and the type of technology;
   TTP ~ f (IFF, TT)..(2)
3. The type of technology is a function of the internal factors of firm;
   TT ~ f(IFF)..(3)

4. The technology transfer performance (TTPerf) is function of technology transfer program and the type of technology involved; and
   TTPerf ~ f (TTP, TT)..(4)
5. The transformation performance is a function of technology transfer performance.
   TP ~ f (TTPerf)...(5)

This study incorporates 5 main variables. These main variables were then broken down into clusters of subvariables. To examine the overall hypothesis, 29 detailed hypotheses were constructed. To examine the 29 detailed hypotheses, each of them was broken down into detailed sub-hypotheses. A total of 545 sub-hypotheses were constructed. All the sub-hypotheses were expressed in terms of null hypotheses (Ho) for the purpose of applying test of association (see appendix 1).

ANALYSIS AND DISCUSSION

The research model developed in this study is intended to provide a framework for examining various variables influencing the transformation performance. Data gathered from the survey and interviews on the 42 construction companies in Malaysia were used to examine relationships between the variables within the model.

Background to The Sample

This research covers a period of 20 years, from 1970 to 1990. 42 Companies involved in this research were established in the seventies and eighties. About 26 companies (62%) were established in the seventies when construction was booming in Malaysia. Amongst the sample, a large proportion of respondents, 28 companies (66%) in this research are in private ownership. 7 companies (16%) are large public companies, a few of them operating in the international arena. 5 companies are state owned where prefabricated housing is the major activity. 2 companies are owned by co-operatives, whose subsidiaries are involved in the less complex construction of low cost prefabricated housing, building of highways intersections and bridges. The majority of the samples were at the early stage of development before entering into a technology transfer program. 29 companies (69%) were in stage 2 or stage 3; searching for alternative technology. 10 companies were already in the process of acquiring alternative technology stage 4 (see table 1).

Table 1: Stage of development before involving in the technology transfer

no	Stage of Development before T. Transfer	Frequency	Percentage
1	Initial stage	2	4.8
2	Developing internal characteristics	12	28.6
3	Searching for alternative technology	17	40.5
4	Acquired alternative technology	10	23.8
5	Transfer technology	1	2.4
6	Total	42	100

ANALYSIS

In this section, analysis was carried out to examine the overall hypothesis of this study
This overall hypothesis was broken down, and shown in Table 2.

Table 2: Summary of Hypotheses

OVERALL HYPOTHESIS		
Main Hypotheses	**Detailed Hypotheses**	**Sub-hypotheses**
Main Hypothesis 1	10	120
Main Hypothesis 2	9	225
Main Hypothesis 3	8	140
Main Hypothesis 4	2	48
Main Hypothesis 5	-	12
Total	29	545

INTERNAL FACTORS OF FIRMS

From the analysis, the subvariables of internal firm factors such as management practice, management style, organization structure, development stage 1, technology acquisition history, technology acquisition objective, technology transfer program and technology transfer were found to be highly and positively related to the transformation performance. Whereas type of ownership and resource factors were found to be relatively weakly related to the transformation performance.

I. Management Practices

The result of analysis shows that, contractors who practiced long range planning in their companies were found to achieve high performance in company's transformation. In terms of practicing management process, most of the respondents emphasized heavily on planning and organizing and less on controlling and leading. Result indicates that contractors who emphasized on planning and organizing achieved high performance in the transformation performance (see table 3).

Table 3: The association tests between sub-variables of Transformation Performance and sub-variables of management practices.

	RELATIONSHIPS	**CHI-SQ**	**Sig. Level**
			P<
	MANAGEMENT PRACTICE		
1	Profitability and importance of long range planning are related.	0.61	0.00
2	Net Asset and importance of long range planning related.	0.54	0.00
3	Devt. Stage 2 and importance of long range planning are related.	0.51	0.02
4	Profitability and practice of long range planning are related.	0.57	0.00
5	Devt. Stage 2 and practice of long range planning are related.	0.58	0.00
6	Profitability and planning are related.	0.56	0.01
7	Net Asset and planning are related	0.48	0.06
8	Development Stage 2 and planning are related	0.51	0.03
9	Profitability and organizing are related	0.59	0.01
10	Net Asset and organizing are related	0.52	0.03
11	Development Stage 2 and organizing are related	0.57	0.01
12	Profitability and controlling are related	0.63	0.00
13	Development Stage 2 and controlling are related	0.58	0.02

14	Profitability and leading are related	0.51	0.02
15	Net Asset and leading are not related	0.47	0.08

II. Management Styles

On the style of management, interpersonal and human relation and superior make decision style seem to highly and positively relate to the transformation performance. Companies emphasized on interpersonal and human relation and superior decision making showed high achievement in the transformation performance (see table 4).

Table 4: The association tests between sub-variables of Transformation Performance and sub-variables of style of management.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	MANAGEMENT STYLE		
1	Profitability and high degree of formal authority are related	0.59	0.01
2	Net Asset and high degree of formal authority are related	0.48	0.02
3	Devt. Stage 2 and high degree of formal authority are related	0.51	0.01
4	Profitability and hi. deg. of interpers. and human rel. are related.	0.61	0.00
5	Net Asset and high degree of interpers. and human rel. are related.	0.54	0.01
6	Devt. Stage 2 and high deg. of interpers and human rel are related.	0.58	0.00
7	Profitability and hi deg dec makg made by superior are related.	0.49	0.01
8	Net Asset and hi deg dec makg made by superior are related.	0.51	0.01

III. Organizational Structure

On organization structure, analysis shows that the respond to changes in the external environment, the rate of change, the informal interaction, the interpersonal and informal coordination and the centralized decision making, the changing and adapting structural form were highly and positively related to the transformation performance.

The majority of the construction companies did respond to the changes in the external environment by changing their internal organization. Changing and adapting the structural form is one of the important characteristics of the organic structure of organization. Other characteristics such as informal interaction, interpersonal and informal coordination, centralized decision making, and faster response to changes in the environment were some of the characteristics that support the organic structure. Result of the analysis shows that construction companies, who adopted an organic structure of organization achieved high performance in transformation (see table 5).

Table 5: The association tests between sub-variables of Transformation Performance and sub-variables of organization structure.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	ORGANIZATIONAL STRUCTURE		
1	Profitability and respond to change to environment are related	0.60	0.00
2	Net asset and respond to change to environment are related	0.54	0.00
3	Devt stage 2 and respond to change to environment are related.	0.58	0.00
4	Profitability and rate of change in the internal structure are related.	0.34	0.06
5	Net asset and rate of change in the internal structure are related.	0.32	0.08
6	Devt stage 2 and rate of change in the internal structure are related.	0.41	0.01
7	Profitability and formal activities are related	0.62	0.00
8	Net Asset and formal activities are related.	0.57	0.00
9	Development Stage 2 and formal activities are related.	0.58	0.00
10	Profitability and one way, top down directives are related.	0.61	0.00
11	Net Asset and one way, top down directives are related.	0.58	0.00
12	Development Stage 2 and one way, top down directives are related.	0.58	0.00
13	Profitability and interaction are related.	0.53	0.01
14	Net Asset and interaction are related.	0.51	0.02
15	Development Stage 2 and interaction are related.	0.52	0.02
16	Profitability and interpersonal and informal coordinatn are related.	0.57	0.01
17	Net Asset and interpersonal and informal coordination are related.	0.52	0.02
18	Devt Stage 2 and interpersonal and informal coordinatn are related.	0.57	0.00
19	Profitability and changing and adapting structural form are related.	0.58	0.01
20	Net Asset and changing and adapting structural form are related.	0.55	0.02
21	Devt Stage 2 and changing and adapting structural form are related.	0.63	0.00

IV. Historical Factors

i. Stage of Development 1

The analysis also shows that the stage of development of construction companies before entering technology transfer program (development stage 1) is highly and positively related to all the three subvariables of transformation performance, in particular with the stage of development after participating in technology transfer (development stage 2) (see table 6).

Construction companies with a higher development stage before entering technology transfer program, achieved higher stage of development after participating in technology transfer. 17 companies (40%) were at stage 3, i.e. searching for alternative technology, before entering technology transfer program and about 50% of the respondents move to stage 6 and 7 (i.e.; the stage of maintain and modify technology and the stage of developing new technology) after leaving technology transfer program.

Table 6: The association tests between sub-variables of Transformation Performance and sub-variables of stage of development 1.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	DEVELOPMENT STAGE 1		
1	Profitability and development stage 1 are related.	0.53	0.03
2	Net Asset and development stage 1 are related.	0.46	0.01
3	Development Stage 2 and development stage 1 are related.	0.77	0.00

ii. Technology Acquisition History

On technology acquisition history, result of the analysis shows that, experience in technology transfer projects and number of local contractors' involvement in the technology transfer projects were positively related to transformation performance. This indicates that construction companies, who had experience in the projects that involved technology transfer, performed better than construction companies without experience. The result shows that, the more experience a company has on technology transfer, the better the transfer performance is and hence, also increased the transformation performance (see table 7).

Table 7: The association tests between sub-variables of Transformation Performance and sub-variables of technology acquisition history.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	TECHNOLOGY ACQUISITION HISTORY		
1	Profitability and experience in t.t. project are related.	0.34	0.06
2	Net Asset and experience in t.t. project are related.	0.32	0.08
3	Development Stage 2 and experience in t.t. project are related.	0.35	0.06
4	Net Asset and no. of t.t. project involved are related.	0.46	0.08

iii. Technology Acquisition Objective

On the technology acquisition objective, all the subvariables were positively related to transformation performance. Majority of the construction companies had given greater emphasis and highly valued construction technology. High performance companies show that they were searching for upgrading existing technology and also searching for new construction technology. Thus, technology acquisition objective is highly and positively related to the transformation performance (see table 8).

Table 8: The association tests between sub-variables of Transformation Performance and sub-variables of technology acquisition objective.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	TECHNOLOGY ACQUISITION OBJECTIVES		
1	Profitability and importance of construction technology are related.	0.54	0.00
2	Net Asset and importance of construction technology are related	0.51	0.01
3	Development Stage 2 and importance of construction technology are related	0.55	0.00
4	Profitability and upgrading existing technology are related	0.43	0.05
5	Net Asset and upgrading existing technology are related	0.49	0.01
6	Development Stage 2 and upgrading existing technology are related	0.51	0.01
7	Profitability and searching for new technology are related	0.46	0.03
8	Net Asset and searching for new technology are related	0.41	0.07
9	Development Stage 2 and searching for new technology are related	0.46	0.03

iv. Type of Ownership

The result shows that, type of ownership was not related to transformation performance. However, among the high performance companies were public and private companies. Other types of ownership, such as sole proprietors and government owned companies, show lower performance in transformation (see table 9).

Table 9: The association tests between sub-variables of Transformation Performance and sub-variables of type of ownership.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	TYPE OF OWNERSHIP		
1	Profitability and ownership type are not related.	0.43	0.29
2	Net Asset and ownership type are not related.	0.44	0.25
3	Development Stage 2 and ownership type are not related.	0.46	0.16

v. Resource Factors

On resource factors, skill resources and the company's net asset show some forms of relation to transformation performance. However, management resources were not related to transfer performance. The possible explanation for this is that, most of the technology transfer program focused on transferring technical expertise to the local contractors (see table 10).

Table 10: The association tests between sub-variables of Transformation Performance and sub-variables of resource factors.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	RESOURCE FACTORS		
1	Profitability and management resources are not related.	0.35	0.62
2	Net Asset and management resources are not related.	0.37	0.57
3	Development Stage 2 and management resources are not related.	0.44	0.26
4	Profitability and skill resources are not related.	0.47	0.17
5	Net Asset and skill resources are not related.	0.45	0.23
6	Development Stage 2 and skill resources are related.	0.50	0.06
7	Profitability and company's net asset are related.	0.55	0.01
8	Net Asset and company's net asset are related.	0.54	0.01
9	Development Stage 2 and company's net asset are related.	0.54	0.01

TECHNOLOGY TRANSFER PROGRAMME

I. Mode of Transfer

On technology transfer program, all sub-variables except for mode of transfer, were related to transformation performance. Only two mode of transfer were involved in this study. They were joint venture and licensing. Most of the construction companies in the study involved in the joint venture type of transfer. 33 companies (60%) were involved in the joint venture. However, only 17 companies (50%) of them achieved high performance. Out of 9 companies involved in licensing type, about 5 of them achieved high performance. There is no evidence in this study showing that, one mode of transfer out performed the other. There were many other factors which influenced the performance. However, both methods had their own merits and did show some degree of success (see table 11).

Table 11: The association tests between sub-variables of Transformation Performance and sub-variables of technology transfer program.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	TECHNOLOGY TRANSFER PROGRAM		
1	Profitability and mode of transfer are not related.	0.07	0.87
2	Net Asset and mode of transfer are not related.	0.29	0.14
3	Development Stage 2 and mode of transfer are related.	0.21	0.40
4	Profitability and training cost are related.	0.56	0.05
5	Net Asset and training cost are related.	0.54	0.07
6	Development Stage 2 and training cost are related.	0.54	0.08
7	Profitability and training duration are related.	0.53	0.02
8	Net Asset and training duration are related.	0.51	0.03
9	Development Stage 2 and training duration are related.	0.53	0.02
10	Profitability and management focus are related.	0.58	0.00
11	Net Asset and management focus are related.	0.49	0.04
12	Development Stage 2 and management focus are related.	0.52	0.02
13	Profitability and technical focus are related.	0.44	0.04
14	Net Asset and technical focus are not related.	0.33	0.27
15	Development Stage 2 and technical focus are related.	0.48	0.01
16	Profitability and involvement of local contractors are related.	0.61	0.00
17	Net Asset and involvement of local contractors are related.	0.55	0.00
18	Devt Stage 2 and involvement of local contractors are related.	0.42	0.02
19	Profitability and technology transfer program are related.	0.46	0.01
20	Net Asset and technology transfer program are related.	0.45	0.01
21	Development Stage 2 and technology transfer program are related.	0.54	0.00

II. Cost of Technology Transfer

The cost of technology transfer was negatively related to transformation performance. This shows that their relationship were inversely proportional. The higher the cost of technology transfer, the lower the transformation performance. Subvariables management focus, technical focus, local contractors involvement and transfer program were also strongly related to the transformation performance. The technology transfer program that highly focused on the management and technical levels shows high achievement in the transformation performance. High level of involvement by local contractors in the transfer program also shows high achievement in the transformation performance. The result also shows that, the transfer program that involved on-the-job training showed higher performance in transformation than the other (see table 11).

Thus, a properly designed technology transfer program, which is low training cost, high training duration, high focus on management and technical transfer, high local contractors' involvement and using on-the-job training program, show high achievement in the transformation performance.

III. TYPE OF TECHNOLOGY

On the type of technology involved in the transfer, the result shows that, types of technology involved were mainly the system specific, firm specific and on-going problem solving and these type of technology were highly and positively related to the transformation performance (see table 12).

Table 12: The association tests between sub-variables of Transformation Performance and sub-variables of the type of technology.

	RELATIONSHIPS	CHI-SQ	Sig. Level
	TYPE OF TECHNOLOGY		
1	Profitability and system specific knowledge are related.	0.44	0.03
2	Net Asset and system specific knowledge are not related.	0.36	0.20
3	Development Stage 2 and system specific knowledge are related.	0.40	0.09
4	Profitability and firm specific knowledge are related.	0.62	0.00
5	Net Asset and firm specific knowledge are related.	0.56	0.00
6	Development Stage 2 and firm specific knowledge are related.	0.55	0.00
7	Profitability and on going problem solving capability are related.	0.64	0.00
8	Net Asset and on going problem solving capability are related.	0.56	0.00
9	Development Stage 2 and on going problem solving capability are related.	0.57	0.00

OVERALL

Overall result of associations between independent variables and the transformation performance variable shows that, associations involving the development stage 2 (the measure of transformation of capability) and profitability (the measure of transformation in terms of financial performance) show stronger relations than the associations involving the net asset performance (i.e. the measure of transformation of capacity). The weaker relations between net asset performance and the independent subvariables may be explained by the fact that accumulation of capacity is relatively slow for any construction company. Most of the construction companies preferred to hire the construction plant and equipment to avoid under utilization of the equipment and also to increase liquidity.

Among the detailed variables of the internal factors of firms that have strong relations with transformation performance subvariables were management practice, management style, organizational structure, stage of development reached before becoming involved in a technology transfer program, technology acquisition history, technology acquisition objective and resource factors. Amongst the subvariables of transformation performance that have strong relations with subvariables mentioned above were the stage of development 2 (i.e. the stage of development after involvement in the technology transfer program) and profitability. The subvariable net asset performance had weaker but still positive relations with majority of subvariables of internal firm factors. Hence, the result of the analysis supports **the main hypothesis 1**; transformation performance is a function of the internal factors of firms, technology transfer program and type of technology.

The main hypotheses 2 and 3, the majority of relationships between subvariables of technology transfer program, type of technology and the internal firm factors were found to be highly and positively related. The result of the analysis shows that the relationships of the three major variables under study were appropriate (see appendix 1).

The main hypothesis 4, the technology transfer performance is a function of technology transfer program and the type of technology was formulated to support that the technology transfer program and type of technology were appropriately designed. The subvariables of technology transfer program and type of technology were highly related to the subvariables of technology transfer performance. Thus, the main hypothesis 4 is supported (see appendix 1).

Analysis, which involved **the main hypothesis 5**, shows that, the technology transfer performance is highly and positively related to the transformation performance. The result shows that high emphasis on the importance of the construction technology, high improvement in the products, production process and the overall technology transfer performance have resulted in high achievement in profitability, net asset performance and development stage 2. Thus, the above analysis indicates that high performance in the technology transfer has also induced high performance in the company's transformation (see appendix 1).

From the above analysis, it can thus be concluded that the overall hypothesis underlying this study: **when the technology transfer program and the type of technology were appropriate to the internal factors of firms, better performance in the technology acquisition can be achieved and will induce better company's transformation performance** is supported**.**

10.0 CONCLUSION

The study has examined the prospect of technology transfer promoting the development of the host country's construction companies, as receivers and users of construction technology. In view of that, it is necessary to investigate factors influencing the variability of transformation of development and inherent potential mechanisms for transferring and acquiring technological and managerial capabilities. The systems approach; and management and organization theory were chosen concepts in identifying the variables, providing a frame of reference and for constructing the research model.

The study has also so far revealed that technology transfer does contribute in some way or another to the development of local contractors. The role and contribution of technology transfer in developing and upgrading the capability and the capacity of the local contractors, as shown in this study, is vital. The technology transfer program involving cooperation between local and international contractors has greatly contributed to the development of local contractors and thus, the objectives of the study were achieved.

This research has shed some light into the process of developing indigenous contractors from small and lack of capability and capacity into contractors that are more capable of doing so. It has also identified various factors (within the scope of the study) that can be considered vital to the development of the indigenous contractors through technology transfer. Findings of the research indicate that some factors have stronger influences on the transformation performance of indigenous contractors than others. Thus, with proper attention to vital factors, the rate of success in transferring the required technology can be expected to be higher.

For the benefit of the Malaysian construction industry and other developing countries, it is hopeful that this research has provided some limited but vital information on the process of technology transfer. Future initiatives in the area must seriously focus on some factors that were identified as vital so as to achieve a greater height of success in the performance of technology transfer. It is the expectation of the author that, the result of this research when put into practice, will contribute to future more positive technology transfer in construction.

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APPENDIX 1: CORELATION TEST RESULT

	LRP	LRM	P	O	C	L	FAU	IR	TO	DM	RCE	RC	FA	OD	I	Co	DEM	SF
LRP																		
LRM	.64*																	
P	.64*	.65*																
O	.76*	.71*	.79*															
C	.53*	.43*	.59*	.76*														
L	.55*	.33*	.39*	.54*	.50*													
FAU	.35*	.38*	.41*	.29	.19	.04												
IR	.59*	.49*	.67*	.58*	.36*	.15	.65*											
TO	.04	.13	.22	.10	.19	.07	.12	.18										
DM	.52*	.34*	.28	.40*	.32	.12	.27	.27	.01									
RCE	1.0*	.64*	.64*	.76*	.53*	.55*	.34*	.59*	.03	.52*								
RC	.57*	.37*	.37*	.47*	.33*	.20	.01	.42*	.22	.12	.56*							
FA	1.0*	.64*	.63*	.76*	.53*	.55*	.34*	.59*	.03	.52*	1.0*	.56*						
OD	.88*	.56*	.49*	.60*	.33	.40*	.44*	.57*	.01	.41*	.88*	.52*	.88*					
I	.68*	.49*	.50*	.47*	.28	.23	.28	.37*	.16	.44*	.68*	.42*	.68*	.58*				
Co	.58*	.34*	.29	.27	.22	.09	.24	.30*	.00	.42*	.57*	.41*	.57*	.51*	.75*			
DEM	.37*	.23	.25	.28	.15	.15	.46*	.39*	.16	.34*	.36*	.35*	.36*	.38*	.28	.40*		
SF	.75*	.50*	.46*	.42*	.15	.33*	.25	.52*	.07	.13	.75*	.61*	.75*	.79*	.47*	.57*	.36*	
SD1	.67*	.25	.20	.34*	.34*	.29	.09	.31*	.20	.22	.67*	.59*	.67*	.63*	.48*	.60*	.36*	.67*
TTEXP	.45*	.26	.40*	.47*	.24	.04	.03	.45*	.29	.03	.45*	.80*	.45*	.41*	.30*	.30	.35*	.51*
TTNO	.45*	.23	.36*	.46*	.25	.06	.05	.40*	.28	.01	.45*	.75*	.45*	.42*	.26	.27	.30	.52*
CT	.82*	.50*	.57*	.64*	.51*	.58*	.36*	.58*	.05	.45*	.82*	.43*	.82*	.72*	.46*	.37*	.26	.60*
UT	.71*	.36*	.37*	.47*	.38*	.25	.30	.47*	.07	.42*	.71*	.32*	.71*	.60*	.48*	.56*	.36*	.54*

NT	.66*	.34*	.47*	.56*	.23	.21	.08	.30	.04	.33*	.66*	.40*	.66*	.51*	.51*	.42*	.25	.51*
OT	.48*	.25	.41*	.60*	.37*	.21	.32*	.40*	.20	.23	.48*	.27	.48*	.50*	.26	.20	.08	.35*
MR	.43*	.38*	.68*	.55*	.41*	.26	.30	.38*	.42*	.17	.43*	.23	.43*	.36*	.40*	.21	.15	.36*
SR	.51*	.55*	.58*	.42*	.23	.09	.39*	.47*	.50*	.14	.51*	.45*	.51*	.47*	.51*	.43*	.30	.59*
NA	.64*	.62*	.48*	.60*	.56*	.32*	.35*	.46*	.19	.44*	.64*	.42*	.64*	.53*	.45*	.49*	.22	.57*
MT	.04	.05	.01	.17	.03	.15	.06	.08	.09	.07	.04	.19	.04	.11	.02	.04	.08	.07
TC	.23	.02	.10	.04	.13	.14	.46*	.25	.30	.30	.23	.07	.23	.44*	.24	.27	.45*	.25
TD	.69*	.49*	.54*	.53*	.36*	.42*	.11	.51*	.19	.28	.69*	.60*	.69*	.58*	.44*	.35*	.23	.73*
MF	.64*	.44*	.57*	.48*	.36*	.26	.33*	.58*	.20	.40*	.64*	.42*	.64*	.59*	.68*	.50*	.34*	.43*
TF	.65*	.67*	.54*	.54*	.37*	.36*	.18	.47*	.24	.14	.65*	.50*	.65*	.64*	.53*	.40*	.19	.68*
LCI	.59*	.52*	.48*	.55*	.29	.23	.53*	.40*	.14	.56*	.59*	.13	.59*	.52*	.41*	.41*	.32	.37*
TTP	.68*	.44*	.34*	.50*	.43*	.29	.13	.43*	.05	.44*	.68*	.42*	.68*	.58*	.47*	.63*	.19	.58*
GB	.22	.13	.03	.24	.12	.14	.27	.41*	.27	.15	.22	.37*	.22	.21	.32*	.27	.28	.24
IS	.14	.10	.14	.02	.28	.14	.41*	.19	.08	.03	.14	.15	.14	.11	.13	.22	.24	.29
SS	.68*	.59*	.52*	.61*	.34*	.36*	.02	.43*	.01	.31*	.68*	.43*	.68*	.55*	.55*	.42*	.10	.50*
FS	.68*	.46*	.53*	.49*	.34*	.30	.24	.60*	.16	.32*	.68*	.45*	.68*	.55*	.55*	.56*	.30	.61*
PS	.69*	.45*	.44*	.55*	.30	.32*	.23	.5*	.01	.26	.69*	.51*	.69*	.55*	.60*	.64*	.40*	.58*
PROFIT	.68*	.52*	.35*	.47*	.31	.21	.54*	.46*	.01	.49*	.68*	.35*	.68*	.71*	.58*	.58*	.44*	.54*
NASSET	.57*	.33*	.13	.33*	.06	.26	.33*	.16	.07	.50*	.57*	.19	.57*	.59*	.44*	.44*	.33*	.44*
SD2	.72*	.43*	.39*	.55*	.59*	.48*	.05	.32*	.23	.30	.72*	.47*	.72*	.58*	.53*	.44*	.11	.55*
TTPROD	.75*	.57*	.69*	.78*	.56*	.32*	.35*	.63*	.14	.44*	.75*	.47*	.75*	.63*	.52*	.33*	.21	.44*
TTPROC	.69*	.54*	.57*	.65*	.44*	.35*	.28	.56*	.11	.19	.69*	.38*	.69*	.54*	.56*	.42*	.30	.48*
TTSOLV	.71*	.40*	.58*	.62*	.43*	.36*	.24	.43*	.12	.24	.71*	.36*	.71*	.67*	.56*	.44*	.28	.54*
TTSATIS	.67*	.59*	.54*	.58*	.34*	.18	.50*	.49*	.05	.40*	.67*	.32*	.67*	.67*	.57*	.50*	.24	.57*

	SD1	TTEXP	TTNO	CT	UT	NT	OT	MR	SR	NA	MT	TC	TD	MF	TF	LCI	TTP	GB
SD1																		
TTEXP	.45*																	
TTNO	.50*	.95*																
CT	.57*	.31*	.29															
UT	.55*	.27	.31*	.60*														
NT	.38*	.40*	.42*	.55*	.61*													
OT	.30*	.27	.30	.49*	.31*	.38*												
MR	.08	.26	.22	.40*	.20	.28	.54*											
SR	.36*	.39*	.35*	.44*	.36*	.41*	.41*	.72*										
NA	.43*	.29	.27	.53*	.38*	.33*	.32*	.47*	.57*									
MT	.05	.31*	.25	.00	.06	.19	.23	.06	.11	.17								
TC	.27	.15	.11	.35*	.28	.03	.19	.05	.18	.15	.11							
TD	.52*	.51*	.50*	.76*	.48*	.46*	.33*	.43*	.48*	.45*	.06	.23						
MF	.38*	.36*	.32*	.56*	.46*	.31	.31*	.56*	.48*	.40*	.25	.38*	.61*					
TF	.42*	.39*	.40*	.48*	.35*	.32*	.34*	.53*	.61*	.61*	.05	.12	.53*	.60*				
LCI	.21	.24	.19	.44*	.38*	.38*	.11	.34*	.26	.54*	.20	.21	.36	.37*	.28			
TTP	.52*	.42*	.41*	.49*	.55*	.48*	.29	.26	.32*	.66*	.15	.19	.44*	.51*	.54*	.53*		
GB	.19	.33*	.28	.25	.24	.22	.34*	.10	.32*	.19	.28	.55*	.29	.24	.15	.08	.15	
IS	.01	.07	.05	.12	.17	.16	.08	.26	.33*	.08	.22	.06	.24	.15	.10	.51*	.05	.08
SS	.39*	41*	.45*	.53*	.42*	.50*	.22	.40*	.34*	.47*	.22	.08	.59*	.59*	.55*	.48*	.52*	.11
FS	.50*	.41*	.41*	.59*	.73*	.60*	.37*	.43*	.53*	.38*	.01	.04	.66*	.58*	.55*	.35*	.55*	.26

PS	.57*	.51*	.46*	.57*	.73*	.62*	.31*	.21	.36*	.35*	.14	.10	.52*	.51*	.49*	.48*	.60*	.24
PROFIT	.51*	.35*	.29	.58*	.35*	.34*	.25	.26	.34*	.55*	.07	.40*	.39*	.50*	.45*	.70*	.51*	.22
NASSET	.42*	.22	.15	.43*	.29	.29	.08	.03	.07	.37*	.01	.37*	.25	.25	.16	.65*	.33*	.03
SD2	.76*	.34*	.42*	.58*	.53*	.37*	.27	.23	.34*	.54*	.04	.11	.52*	.47*	.54*	.29	.59*	.15
TTPROD	.37*	.41*	.42*	.64*	.60*	.57*	.59*	.54*	.49*	.52*	.17	.05	.60*	.57*	.55*	.38*	.52*	.20
TTPROC	.38*	.38*	.39*	.51*	.66*	.50*	.24	.25	.27	.35*	.14	.02	.48*	.48*	.48*	.45*	.54*	.21
TTSOLV	.25	.30	.35*	.48*	.56*	.49*	.42*	.53*	.34*	.37*	.11	.10	.51*	.68*	.59*	.43*	.57*	.05
TTSATIS	.25	.33*	.30	.58*	.53*	.57*	.58*	.67*	.66*	.59*	.12	.27	.49*	.53*	.66*	.55*	.53*	.29

	IS	**SS**	**FS**	**PS**	**PROFIT**	**NASSET**	**SD2**	**TTPROD**	**TTPROC**	**TTSOLV**
IS										
SS	.07									
FS	.27	.63*								
PS	.25	.57*	.80*							
PROFIT	.29	.58*	.46*	.52*						
NASSET	.22	.39*	.16	.39*	.78*					
SD2	.09	.53*	.44*	.41*	.46*	.31*				
TTPROD	.06	.55*	.61*	.55*	.32*	.11	.56*			
TTPROC	.25	.54*	.61*	.74*	.35*	.17	.57*	.73*		
TTSOLV	.14	.51*	.53*	.49*	.35*	.16	.41*	.63*	.66*	
TTSATIS	.31	.50*	.60*	.52*	.59*	.32*	.30	.65*	.47*	.65*

* - Signif. LE .05

ABREVIATIONS

LRP - Long Range Planning
LRM - Long Range Management
P - Planning
O - Organizing
C - Controlling
L - Leading
FAU - Fix Assets Acquisition
IR - Interpersonal and Human Relation
TO - Technology to Other Firms
DM - Decision Making
RCE - Respond to Changes Occur in the External Environment
RC - Respond to Changes
FA - Formal Authority

<u>OD – Internal Organizational Change</u>
I - Internal Activities
Co - Co-ordinations
DEM – Decision Making
SF - Structural Form
SD - Stage of Development
TTEXP - Technology Transfer Experience
TTNO – No. of Technology Transfer Projects
CT - Construction Technology

UT - Upgrading Technology
NT - New Construction Technology
OT - Overall Performance of Technology
MR - Management Process
SR - Satisfied with the Results
NA – Net Asset
MT - Maintaining and Modifying Technologies
TC - Technology Capabilities
TD - Technology after Diagnosis
MF - Motivated in the Firm
TF - Technology to other Firms
LCI – Local Contractor Involvement
TTP - Technology Transfer Programmed
GB - General Business
IS - Industry Specific
SS - System Specific
FS - Firm Specific
PS - Problem-solving
PROFIT **-** Profitability
NASSET - Net Asset Performance
SD2 - Stage of Development After Tech Transfer
TTPROD - Technology Transfer Product
TTPROC - Technology Transfer Process
TTSOLV - Technology Transfer Solve
TTSATIS - Technology Transfer Satisfied

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Students Leaving Home and Entering the Housing Market

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Abstract
This study is about the housing demand for students. This research examines the students' housing choice, in order to explore the students' pattern of living in greater depth and to obtain a better understanding of their needs and how they might be linked with the students' attraction for a city. This research was conducted at the Universidade Regional do Noroeste do Estado do Rio Grande do Sul (UNIJUI), in Ijuí, south of Brazil. The data was collected from university students. Initially, research focused on how and why young students leave the parental home and enter the housing market. After that, we analyzed the housing preferences expressed by these students with the stated preference method. In summary, the results show that the students left the parents' home due to the course type, paid activity, the distance between the parents house and the university, age, marital status, number of disciplines, financial dependence, own income; parents'income and financial support value.About the housing choice, the rent and the arrangement are the more important attributes. The students prefer cheaper habitations and also prefer to live near the university, in habitations with furniture, in habitations with better comfort. Thus, it is important to know more about the housing-market, independent from the location in the world.

Keywords
Housing-market, students, leaving home, housing choice.

INTRODUCTION

The expansion of the higher education sector has taken place with minimal attention given to housing in this growing student population. The increased demand has resulted in the establishment of niche student markets. The High school students' population in Brazil has become expressive along the years. The literature on housing demand sustains that the students are a specific group of youth that begin to impact the housing market [Rugg et al (2000), Christie et al (2002), Mulder and Clark (2002)].
Observing the housing demand for students and its impact on local housing markets, this research examined the housing-market entry of nest leavers. Leaving the parental home and becoming

independent is the first step in the life course to family formation, household creation and housing-market participation [Clark and Mulder (2000)].
This research was conducted in the Universidade Regional do Noroeste do Estado do Rio Grande do Sul, in the south of Brazil. Initially, we investigated how and why young students leave the parental home and enter the housing market. After that, we examined the housing preferences expressed by these students with the stated preference method.

RESEARCH BACKGROUND

Literature on the students leaving parents home

Several studies have driven attention to the leaving of young people from parents' home, among them students. Some studies particularly make a difference between the terms "leaving home" and " living away from home". For [Leonard (1980) *apud* Jones (1987)] the first refers to a definite move and the latter is a reversible case, which occurs when the children live in another place for a period of timein order to study or work, keeping the housing link with parents.
This viewpoint is also focused by Galland (1997), who differentiates these two situations from the perspective of financial dependence. The author claims that the basic difference is in affording his expenses or having parents' financial support. Leaving home is connected to the access to independent residence, and living away from home happens when the young adult keeps bonds with his/her parents and it often means financial dependence from parents.[(Galland (1997)].
According to Galland's definition, most students would be includedin the group where parents pay for the housing. Only after finishing their studies they settle an independent home [Avery *et al.* (1992), Mulder and Clark (2002)].
Nave-Herz (1997) researched the students' housing situation in Germany and shows that in1994, 21% lived with their parents, 40% lived in flats, 20% shared a flat with other people and 13% in students housing (at university) and the other 6% shared tenant rooms from rented buildings.
Two studies focusing on students'segments deserve more attention. Hensher and Taylor (1983) identified the factors which influence the students' decision about their housing location and determine the fact of moving or not moving fron house during their study time. The case study was carried out in Sidney and investigated a sample of 200 students.
In the research by Hensher and Taylor (1983) three categories of variables were identified as conditioning in the decision of moving away made by students: accessibility, financial dependence and residence composition. The variables income, housing cost and the quality of housing have not presented any apparent significance in the decision of moving.
Another important aspect which must be noticed in the research of Hensher and Taylor (1983) is the existence of differences in the reasons given by students and those mentioned in the studies about mobility involving people as a whole. The explanation is related to the fact that, for students, the housing choice is a transitory and short-term decision.
Regarding the choice town where to live, Hedriks(1985) developed a work aiming to reveal the way students attractiveness study place. The author interviewed 73 students of the first year at Nijmegen University, who at the time could have chosen between five towns where to attend the course. The model of decision process used pointed as results, in nature and importance order, the following attributes: distance, quality of town, aspects related to friends, size of town, previous knowledge of town, housing conditions, teaching conditions, characteristics of the university, bonds with their first housing (most students have already lived in this town) and other reasons. The end of the

studies involve a decision process between coming back to live with their parents or entering the housing market[Mulder and Clark (2002)].
In England, 48% of young adults who have left home to study came back to live at their parents' home, suggesting that the accesss to education characterizes only a temporary phase in the housing career of young adults [Jones(1987)]. In the USA,60% of those who leave their parents' home to study or for military service come back home and in Australia about 45% [White (1994) *apud* Murphy and Wang(1998)].

Literature on the housing choice of students

As observed by Kruythoff (1994), the students are a specific group of young adults who enter the housing market, who, in its majority, do not work and use small and low cost housing. Some studies found on the literature which focus the students' demands are summarized in Table 1.

Table 1. Synthesis of the main studies about students' housing choice

RESEARCH	OBJECTIVES AND SAMPLE	METHODO	RESULTS
Shinn (1970)	Housing choice. United Stated students.	To evaluate housing sceneries.	Type and quality were the more significant variables. Location did not seem important.
Sugden; Willians (1973)	Housing choice. York (England students).	Linear Regression.	The commuting cost between home and the campus were the most significant variables, none of the variables related to housing were significant
Louviere; Henley (1977)	Housing choice. 50 students	Hypothetical sceneries (three rents, different distances and times)	There was no compensation of attributes, for example, flats a long distance from the university were not attractive even offering high quality and low cost; it was observed that individual preferences may be extended to groups with socio-economic similar characteristics.
Hensher; Taylor (1983)	Housing mobility of 200 students in Sidney.	Multiple Regression	Significant variables for mobility: accessibility, financial dependence and residencial composition. The variables of income, housing cost and the quality of housing were omitted by students not presenting significance in the decision of moving. The final model omitted the variables of commuting cost and accommodation cost and total cost.
Hendriks (1985)	City choice for to study 73 students of Nijmegen University.	Revealed preference.	The following attributes were important in the choice of town: distance, quality of town, aspects related to friends, town size, previous knowledge of town, housing conditions, teaching conditions, characteristics of the university, bond with the first housing and other reasons.

Source: (BRANDLI; HEINECK, 2003).
All these studies show different applications and results, because there are external variables that influence the decision process model, which comprehend the values system, the motivation, the

level ofinformation and the personal characteristics of the individuals. To sum up, the factors which influence the reasons of each person's choice. The decision process depends on the individual perceptions and the attractiveness of the choice alternatives.
However, it is common sense that this market segment has peculiar characteristics and its expressiveness translates impact in the housing market.
Another group of researchers have focused their attention on the supply side, evaluating this impact through the ways by which the local agents respond to the students' demand [Chatterton (1999), Kenyon (1997), Rugg *et al.* (2000), (Smith (2002)].
For Rugg et al. (2000) this impact depends on the nature of the market and the bargain power of the other demanding segments. The author comments that in York/ England, the students' concentration tends to induce the owners to rent their properties in the areas occupied by them once the neiborhoods' characteristics keep changing due to the differences of students' life styles. Concerning the offer, the housing conditions vary depending on the location. In areas of lower demand facilities are offered in order to attract students (microwave oven and cable TV in the housing, for instance). In areas of higher demand, the students pay for lower quality housing.
According to Smith (2002), the impact of the magnitude and the concentration of students' housing in the town are social, economical, cultural and political oriented and it has attracted significant local, regional and national interest.
Chatterton (1999) explores the role of university students in the construction entertainment sites in the city of Bristol. He shows that the economic, cultural and educational vitality of the city are intrinsicaly related to the students attracted by the university.
The study by Kenyon (1997) reveals that the students are perceived by the local residents faced with the negative impacts in the neighborhoods physical and social characteristics.
These arguments corroborate to what Chrisafis (2000) identifies with the families living in students' neighborhood that the presence of students residents causes discomfort.The significant number of rented housing, where most of the owners are investors, added to the students' life style (noise, lack of care with the housing and its sorroundings) bring compatibility problems between the neighborhood's residents.
Smith (2002) evaluates the economic importance of this segment and shows that students have preferences and likings well defined by peculiar types of housing, location and rent value.
Another important observation is that several students move from the university accommodations to a place rented in the local housing market. This transition occurs, most of the time, in a beneficial way, by making it feasible the consumption of an specific kind of housing, giving the opportunity of the co-residence with friends of his/her choice and potencializing the experience of independent housing.
The geographical location of students shows a similar tendency in the results of Rugg *et al.* (2000) and Smith (2002). The students group in specific areas or near the university (in this case to minimize the costs and time of transportation) or in downtown áreas (due to job opportunities, cultural and entertainment facilities such as cinemas, shops, bars and other amenities).

METHODOLOGY

Data, sample and survey for the leaving parents' home

The data was collected from 242 university students and a logistic-regression model was used. The questionnaire aimed to discover the interviewees' current choices. It was structured with a part in common: graduate course characteristics and socioeconomic characteristics.

The variable for analysis was denominated Housing Condition (CONDITION), where Y1 = {1, 2}, binary and dichotomic, with events mutually exclusive and independent, in that it had attributed 1 to the factor “left from the parents home”, and 2 to the factor “lives with parents”. The regression model was obtained with the software Statistical Package for Social Sciences (SPSS) 8.0.

Data, sample and survey for the housing preference

The data was collected from 450 university students and uses an econometric model using stated preference data to examine student housing choices.

The survey was realized during July, August and September 2003. The total sample was randomly selected and m restricted to UNIJUI students that have left parental home.

The identification of the attributes considered as influence sources for the choice was accomplished based on the recommendation of Bradley and Daly (1994). The hypothetical scenaries are as similar as the actual choice situations. For this, the characteristics of the choice alternatives were defined from an exploratory study and from the bibliography.

Besides, it was considered that, even if the housing characteristics can be described by a great variety of components, these components have different importance depending on the market [Tu and Goldfinch (1996)]. Based on this and on the specific literature on students’ housing choice the attributes that could influence the choices of this segment were defined. The analysis includes the following structural characteristics: (1) quality; (2) arrangement;(3) rent or cost; (4) location; (5) furnished housing; (6) comfort.

ATTRIBUTES	CODE	LEVELS - CHARACTERIZATION
Quality	0 1	Level I – less satisfaction with acoustic, heatstroke, illumination comfort Level II – more satisfaction with acoustic, heatstroke, illumination comfort
Arrangement	0 1	Level I – live in group (friends/partners/relatives) Level II – live alone
Rent or Cost	0 1	Level I – R$150,00 Level II – R$ 300,00
Location (accessibility)	0 1	Level I – downtown (shops/supermarkets accessibility) Level II – proximity to the university (campus)
Furnished housing	0 1	Level I – habitations that don’t incorporate furniture Level II – habitations that incorporate furniture
Comfort (use)	0 1	Level I – worst space per person, privacy and independence in the use of the kitchen and bathroom Level II – better space per person, privacy and independence in the use of the kitchen and bathroom

Fig. 1 Attributes and levels

ANALYSIS AND RESULTS

The leaving parents’ home

The model that explains the leaving parents’ home, with explanation R=88,82%, shows that the main explanatory variables of the housing situation were: the course type, paid activity, the distance between the origin city and Ijuí, age, marital status, number of disciplines, financial dependence, own income; parents'income and financial support value. Equation 1 and Table 2 show the results from this part.

$$Y'=0{,}5271+0{,}0706X_1-4{,}7527X_{21}-3{,}1035X_{22}+3{,}262X_{31}-1{,}4385X_{32}+0{,}2131X_4-1{,}7017X_{51}+0{,}0013X_6-0{,}0002X_7-2{,}305X_{81}-0{,}0016X_9+2{,}4921X_{101}-0{,}0476X_{102} \quad (1)$$

The young people who leave the parents' home maintain a relationship of financial dependence with them. These young people have a higher family income than the ones who don't leave, capable to finance this exit.
The work place is a significant variable and the main influence in the residential location. This way, the work acts as a factor of impediment of the mobility.
The change probability is directly linked to the commuting time contemplated for the distances between the origin city and the university.
There is a larger probability of changing when there are government financial resources or other sources, but not when the funds are from the own students.
The final model omitted the variables commuting cost and accommodation cost (cost of living with the family, with friends) and total cost (both).
The graduation course type regarding the period of the classes indicates that the night period contributes to the displacement and the avoidance of leaving out. The day courses, on the contrary, induce students to settle home in Ijuí. The full-time courses didn't have significant difference between the two groups and tend not to set importance to the return.

The housing preference

The utility function expresses the viewpoint of the students about the housing attributes, representing mathematically the importance given to each one. The positives signs of the coefficients denote the utility increase when the level 0 changes to 1. The values of the coefficients mean importance level of an attribute and show what parameters are significant.
The utility function obtained from the SP statistical adjustment for the total sample is presented in equation 2. Table 2 shows, for each attribute, the value of the coefficients, the error, the t -test and the confidence interval.
The utility function for SP model is given by:

$$U_{SP}=-0{,}0711X_1+0{,}3587X_2-0{,}7676X_3+0{,}0265X_4+0{,}3132X_5+0{,}5726X_6 \quad (2)$$

Where: X_1 = quality; X_2 = arrangement; X_3 = rent; X_4 = location; X_5 = furnished housing; X_6 = comfort

Table 2. Stated preference results

Attribute	Coefficient	Error	t-test	CI (t=2.5%)
Quality	-0.0711n/s	0.1072	-0.6629	[-0.286; 0.143]
Arrangement	0.3586	0.1089	3.2943	[0.141; 0.577]
Rent	-0.7678	0.1151	6.6666	[-0.999; -0.538]
Location	0.0265 n/s	0.1072	0.2471	[-0.188; 0.241]
Furnished housing	0.3133	0.1085	2.8874	[0.096; 0.530]
Comfort	0.5723	0.1116	5.1321	[0.350;0.796]
Number of interviews: 450		Number of cases: 450		
L (max) = -623.8325		L (C)= = -563.4567		
LR (-2[L(max) – L (C))]= 120.7516		ρ^2 = 0.0968		

n/s – not significant at 5% level.

The results show the rent as the most important attribute in the choice of the habitation for the student, followed by comfort, arrangement and furnished housing. Location and quality didn’t present statistical significance at the 5% level.
The attribute cost, or rent value is negative and highly significant as expected. In the SP model it was the most important characteristic for the housing choice.
The comfort, defined by space per person, privacy and independence in the use of the kitchen and bathroom presents more utility in the satisfactory condition, with privacy and independence than in the contrary condition.
The arrangement coefficient was negative indicating a preference for individual arrangement. This explanation is behavioral.
About the furnished housing, the behavior shows that the students prefer habitations with furniture, habitations that incorporate furniture rather than the ones that don't offer any.
The location attribute didn’t obtain significant coefficient, it can be explained by the fact pointed by the literature that both possibilities offered to the students downtown and proximity to the university, are attractive and they possess balanced preferences among the students. The quality was not significant either.
The SP utility analysis shows that the best housing situation is: less quality, live alone, rent of R$ 150,00, proximity to the university, habitations that incorporate furniture and better comfort (utility value = 1,2716). On the other hand, the worst housing situation is: more quality, live in group, rent of R$ 300,00, downtown, habitations that do not incorporate furniture and less comfort (utility value = -0,8397).

CONCLUSIONS

This paper focused on two aspects of student life, the leaving parents’ home and housing choices. The objective was to explore the pattern of living of the students in greater depth and to obtain a better understanding of their needs. To know their preferences and choices can help to new construction projects in the niche market.
About the results, in this particular study, we can show that the students left the parents’ home due to the course type, paid activity, the distance between the origin city and the university, age, marital status, number of disciplines, financial dependence, own income; parents’ income and financial support value. About the housing choice, the rent and the arrangement are the more important attributes. The students prefer cheaper habitations and also prefer to live near the university, in habitations with furniture, in habitations with better comfort.

In summary, the results show similarities to the theoretical background, in other cities and in other countries. It is important to know more about the housing-market, independent from the location in the world.

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Cost of Construction Equipment In Developing Countries

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Abstract
When you move away from the capital cities, in many countries, it is common that equipment is retained and used for duration that are much greater than its normal economical life. Market conditions in many countries force contractors to keep the equipment in use for longer time periods rather than considering disposal and replacement. This research focused on the conditions for making equipment ownership decisions and how a contractor can maintain a profitable business in the local markets of developing countries. It specifically examines conditions in the northern part of Peru.

By comparing the market prices for construction services in northern Peru against total equipment costs it was possible to develop an idea of the margin available for equipment utilization. Equipment operation costs were obtained by interviews with local contractors and equipment owners. It was found that market conditions, and government and legal policies are factors that influence profit and ownership costs. The maximum economic life of a machine needed to recover the investment was found to be thirteen years. Ownership cost for new equipment is 1.8 times the operating costs and local prices do not offer sufficient margin for major machine overhauls. This happens more noticeably in the case of graders and tractors for which there is a low demand. Because of greater demand for trucks and front-end loaders they tend to be more profitable. This research should help contractors in making informed equipment decisions and in understanding local market conditions that affect new equipment technology.

Keywords
Equipment cost, equipment life, equipment technology, profit.

INTRODUCTION

The use of construction equipment on a project permits greater productivity and permits improved quality but there is a considerable capital investment required in obtaining the machines. The use of rental equipment is a worldwide practice and it is growing in Peru. In Peru, the purchase of new equipment is mainly by the municipalities. Municipalities or government institutions are responsible for infrastructure development of the cities, urban development, building hydraulic and sanitary facilities and urban roads. The army is the second government institution that purchases heavy equipment. Its use is primarily for the construction of rural roads. Private contractors purchase very few new pieces of equipment, mostly for quarrying operations. The purchase of machines is normally supported by loans from commercial banks.

Thanks to governmental policies, local municipalities and other government institutions have acquire a extensive fleets of modern equipment during the last ten years. When local government institutions perform construction work with their own equipment it reduces the demand for local contractor equipment. It is a situation that minimizes the employment of private equipment. Public organizations have a tendency to prefer constructing project on a day labour basis with their own equipment instead of contracting with private companies. This contracting system is commonly known as direct administration. Additionally, there are very few projects that require large fleets of heavy equipment.

Most of the heavy equipment in northern Peru is old, some very old. It is used on jobs where production is not critical, so machine down time for repair is acceptable. Besides the lack of high production requirements, the low number of possible annual operating hours is another factor that causes contractors to keep old equipment for long periods of time. The most commonly used pieces of heavy equipment in northern Peru are track dozers, wheel front-end loaders, graders, and trucks, but some hydraulic excavators are also to be found. The manufacturers serving the market are Caterpillar, John Deere, Komatsu, Kenworth, and Volvo. Older bulldozers and trucks used on the San Lorenzo Dam project (constructed between 1950s to 1960s) can still be found in operation on projects today.

In general, unstable economics, the political situation, low taxation, reductions of budgets and the absence of significant engineering projects are factors that greatly impact equipment decisions in many countries including Peru. Local contractors affirm that equipment, which is purchased used, must be employed on projects at least seven months per year to be economically viable. In the case of new equipment, utilization requirement is close to twelve months per year.

The total cost of equipment is comprised of both ownership and operating costs. The older the equipment, the less ownership cost becomes a factor, however with age operation cost increases. Therefore, there is point when operation costs are so high that is not economic to keep the equipment and it is better to dispose of the machine and find a replacement [Schaufelberger, 2002]. Determination of a machine economical life is a critical business exercise. By simulating several typical ownership cases it is possible to establish a range of economical machine costs based on local conditions.

Operating costs will vary considerably depending on the type of work, local prices for fuel and lubricants, and tires if a pneumatic tired machine. The mechanics or companies providing maintenance services have maintenance and repairs cost data; owners have fuel, grease, and filter cost data, and operating hour data. Based on data supplied by many local contractors and recognizing that some of these entities only maintain partial records various averages can be established. But because the data comes from many sources, the compilation of operating cost requires discretion in selecting appropriate data to use in establishing economic life and the impact of different life spans on the total cost of the equipment.

OWNERSHIP COSTS ANALYSIS

Ownership cost is a critical component to business decisions concerning equipment. The costs of ownership are influenced by the specific conditions of machine acquisition, but mainly by the particular conditions of the owner: the financial arrangements for the purchase, management of the company, type of work the company typically performs. For that reason, it is not easy to establish a single value but it is possible to establish the limits and range that provide a reference for the final comparison with the total costs. Local information concerning ownership cost was solicited directly from owners and mechanics.

Average machine purchase prices have been determined for both new and used equipment. These are prices typical to northern Peru. Salvage values have been developed based on four year of use, from the time of purchase, for both machines purchased new and for those purchased used. Financial conditions are variable, but the interest rates available in northern Peru range between 12% and 22%.

Table 1 Purchase Price and Salvage Value for new and old models equipment (US $,000).

Models	Valor	Dozer	Hydraulic excavator, loader	Grader	Truck
New	Purchase	$180-200	$120-140	$170-180	$140-150
	Salvage value	60- 80	70- 90	80- 70	50- 60
Old	Purchase	15- 25	15- 25	15- 25	20- 25
	Salvage value	10- 20	10- 20	10- 25	10- 15

Unless there is a specific contract requirement to do so machine owners do not typically insure their equipment. Therefore, insurance was not considered as ownership cost for this research. In Peru, taxes have little impact on machine cost since they are only 0.6% of the excess over 1.5 million dollars of asset value (Law no. 28424, of the 21.12.04). Local companies do not usually have asset valued above these limits.

Through interviews with individual owners and mechanics it was possible to develop typical values for machine operating hours per year (Table 2). These operating hour values seem low and there is very little difference based on machine type. This fact partially explains the results found in this research.

Table 2 Average hours of operation per year for heavy equipment in Piura.

Models	Track Dozer	Front-end Loader	Grader	Truck
Old	1000	1000	1000	1000
Modern	2000	3000	1000	2000

Four acquisition cases can be defined as representative of local market conditions:

1. Purchase of a new machine, used only for its economical life. In this case, economical life period is approximately four years.

2. Purchase of a new machine, used for a duration that is greater than the machine's economical life. This case represents the most frequent condition found in northern Peru, since owners invest in successive repairs until the machine is only scrap iron. Common ownership duration in this case is 15 years or more.
3. Purchase of a used machine, used for a period of approximately four years.

4. Purchase of a used machine, used for a duration that is greater than machine’s economical life–until the machine is only scrap iron. This case represents another occurrence in northern Peru and the ownership duration in this case is 15 years or more.

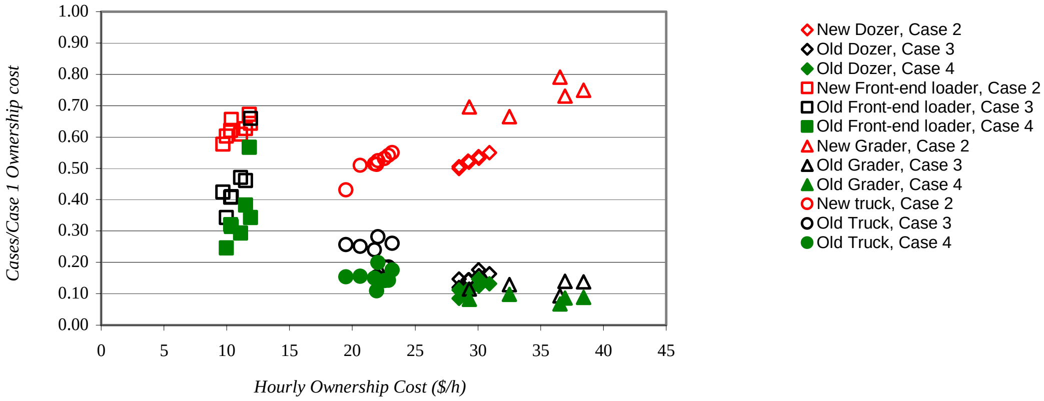
The basic formula for determining ownership cost is:

$$Ownership\ \text{cost} = \frac{(Purchase\ \text{Pr}\,ice - Salvage\ Value)}{Duration\ of\ \ use}$$

[1]

A comparison of the ownership cost for the four cases is presented in Figure 1. The values given were derived by calculating the ratio of the cases 2, 3 and 4 ownership cost by the case 1 ownership cost. This figure illustrates the reason many owners chose to employ used equipment or to keep machines in use for longer duration.

Figure 1 Variation of ownership cost in respect to case 1 ownership cost (Purchase of a new machine, used for only 4 years).



As was expected, ownership cost varies significantly depending on whether a machine is acquired new or in a used condition. The variation is also influenced by the duration it is kept is service–the expectation to recover the investment over only 4 years or if the owner will invest in more repairs and use the machine for 15 or more years. New equipment used more than 15 years (case 2) has a cost of ownership between 43% and 79% of ownership cost for the same equipment used only 4 years. Nevertheless, if the equipment is purchased used (cases 3 and 4), there is a very little ownership cost difference if it is used for only 4 more years or for more than 15 years.

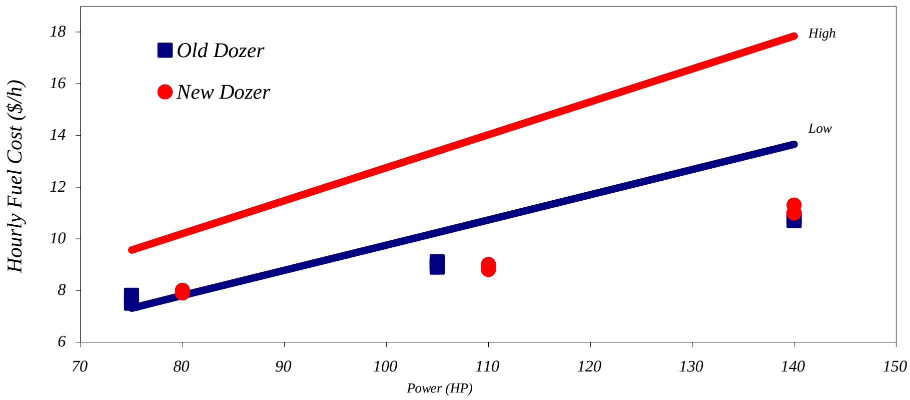
It is not business investing in own equipment, unless there is a contract that can support the minimum economical life hours itself or a quarrying job. After that contract or the quarrying job finish, the best choice is convenient keep the equipment, investing in maintenance al least for 15 years, because taxes and insurance expenses will not represent too much total cost increment.

OPERATING COST ANALYSIS

The operating costs include the cost of repair and maintenance, fuel and services (oil, grease, manual labour and lubricants). Data used in this research was based on information provided by owners and mechanics. The owner supplied fuel consumption and lubricants data, according to use hours. The mechanics provided data concerning the costs for keeping a machine in working condition. To relate the information to US dollars, an average fuel price of US$ 2,50 per gallon was used (January 2004).

Fuel costs were compared to fuel consumption load factors suggested by manufacturers, which offer high and low range, for dozers, front-end-loaders, graders, and trucks [Peurifoy and Schexnayder (2002), Caterpillar Tractor Co. (2001)], (Figure 2, crawled dozers). As it was expected, fuel consumption increases with engine power.

Figure 2 Fuel Costs for Crawled Dozers.

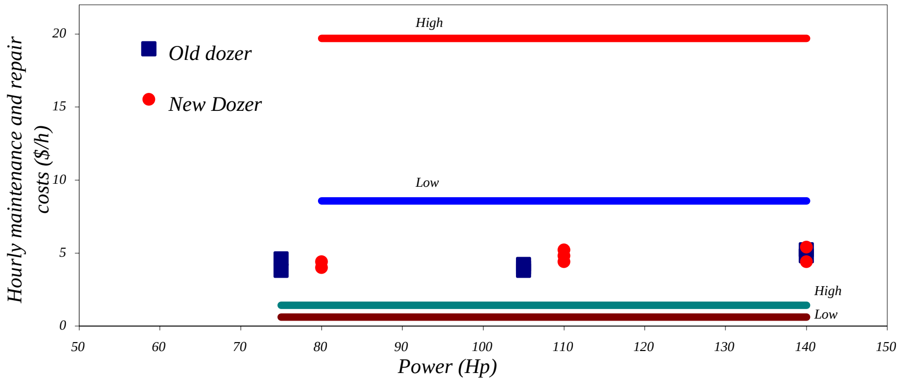


Some machines were not maintained well–the owners did not have a regular maintenance program for their equipment. These still had lower fuel consumption rates than the new machines, which were maintained with efficient maintenance programs. In all equipment, real fuel costs are less than favorable conditions range, even if it is old. It seems that conditions of the machine does not influence fuel consumption.

The maintenance and repair costs (both preventive and corrective maintenance) are usually considered as a percentage of fuel cost [Peurifoy and Schexnayder, (2002)]. Estimating has been compared to real data. Hourly cost for repair and maintenance ranges between US$ 3.80 and US$ 5.40 for dozers; US$ 4.00 and US$ 5.40 for front-end-loader; US$ 3.20 and US$ 4.70 for grader; and US$ 2.40 and US$ 3.20 for trucks. No relationship was observed between repair and maintenance costs and fuel consumption.

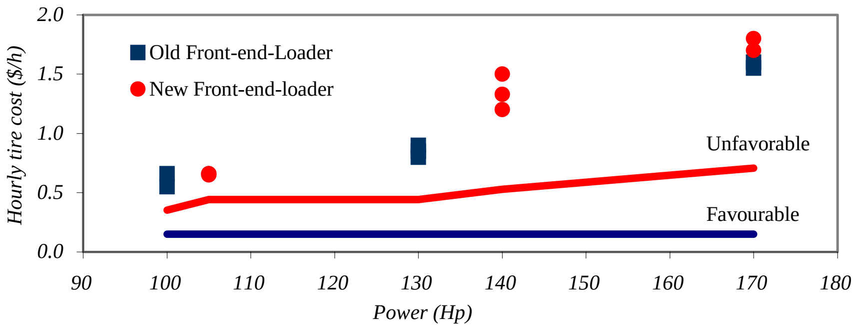
Figure 3 shows repair and maintenance costs for both old and new dozers. It is also presented for high and low load factors range. No repair and maintenance costs and engine power relationship can be proposed. But, again, no significant difference between old and new equipment can be observed in data.

Figure 3 Repair and maintenance costs for crawled dozer.



Comparing estimated tire costs for favorable and unfavorable conditions against real data it was found that actual estimating formulas underestimate tire cost as compared to that experienced in northern Peru. Tire cost for graders, front-end-loaders, and trucks tend to increase as engine horsepower increases. This increase is also due to the intense employment of the larger units in quarry activity. Figure 4 shows front-end-loader tire data.

Figure 4 Tires cost for front-end-loaders.

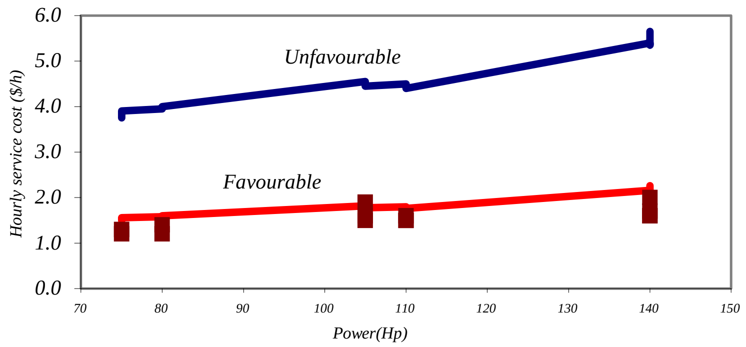


Tire cost for old trucks were closer to average conditions suggested by estimating practice. In northern Peru, the practice is to only replace tires when they are completely useless. On the other hand, old trucks are usually carry overweight loads, which causes increased tire repair costs. The estimated tire cost for the case of new trucks usually provides values below what actual data suggests. This may be the result greater usage on jobs with unfavourable conditions.

Service costs include lubricants (oils and grease) and filters. It is usually expressed as a percentage of fuel cost, for different conditions of operation. For dozers, front-end-loader, graders, and trucks, service costs were less than 20% of good condition fuel costs. The Figure 5 shows service costs data for dozers.

The expenses for service tend to be uniform for both old and new equipment (dozers, trucks, graders, and front-end-loaders). It appears that in northern Peru the operating conditions are generally good. Estimating service costs as a percentage of fuel cost could still be a good approach. In northern Peru, different percentage values can be proposed: 17% for dozers and trucks; 15% for front-end-loader; and 16% for graders.

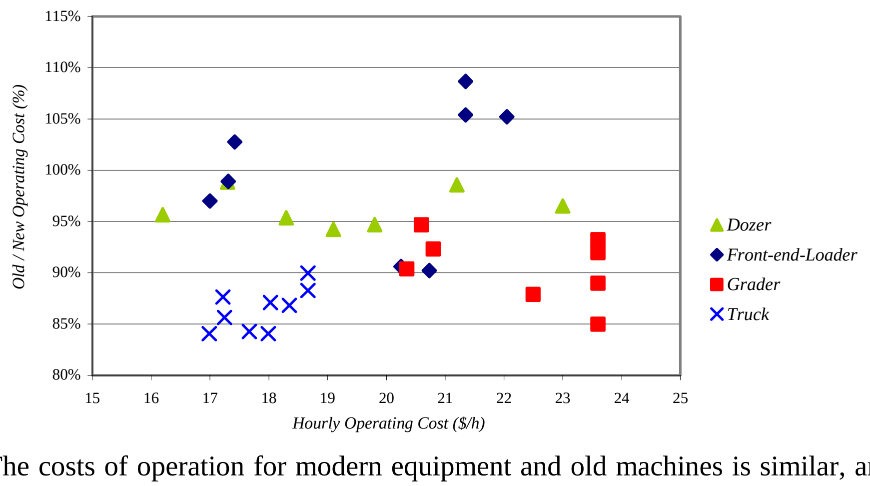
Figure 5 Service cost for dozer.



Operating costs tend to increase with the usage or the equipment [Peurifoy and Schexnayder, (2002)]. This characteristic of operating cost is critical to defining the economic life of the equipment and is the critical factor differentiating the economics between using machines for only a few years instead of keeping it for longer periods of time.

Figure 6 shows variation of old machine operating costs calculated as a rate of new machine operating costs (old machine operating cost divided by new machine operating costs). It can be seen that in most of the cases, old machine operating costs area less than new machine. An exception is the older frontal-end-loader, which has almost 10% greater costs than new equipment. This could mean that operation conditions in the field, type of job, and less operation hours than average in northern Peru generate good conditions for the operation and low cost for old equipment. On the other hand, it could also mean a low investment on maintenance and repair of old units and much more money investment in new units. With the information from the local market it is not possible to develop a clear conclusion.

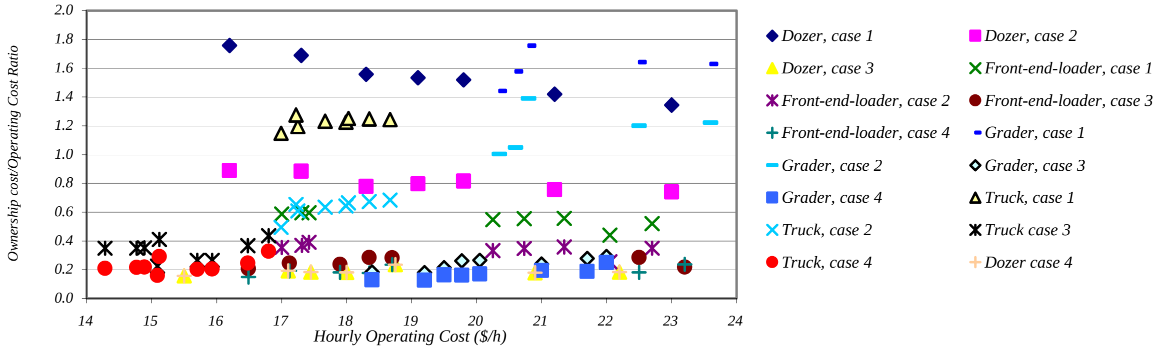
Figure 6 Variation of operating costs of old machine respect to new equipment.



The costs of operation for modern equipment and old machines is similar, and this means the total cost has the ownership costs tendency. While this analysis does not consider cost versus production, it means that equipment owners believe it is better to keep older equipment in their fleets. It also explains why owners dedicate significant efforts to maintaining their machines. For this reason, it is difficult to define an economic life, since total cost diminishes in time. If companies want to be competitive, buying new equipment is not necessary but keeping a permanent and complete maintenance program.

Since the ownership costs is variable, comparing them to operating costs, it is possible to establish an order of magnitude for the total cost. It can be observed that ownership cost ranges between 0.15 for old equipment and 1.80 for new equipment, depending on conditions of purchase and the time of possession, figure 7. Using this ownership/operating costs ratio, maximum margin was plotted against ownership costs ratio for both, new and used machine. For both new and used machine, two cases of ownership duration are considered: 4 years ownership duration and 15 years or more ownership duration.

Figure 7 Variation of ownership costs in respect to operating costs.

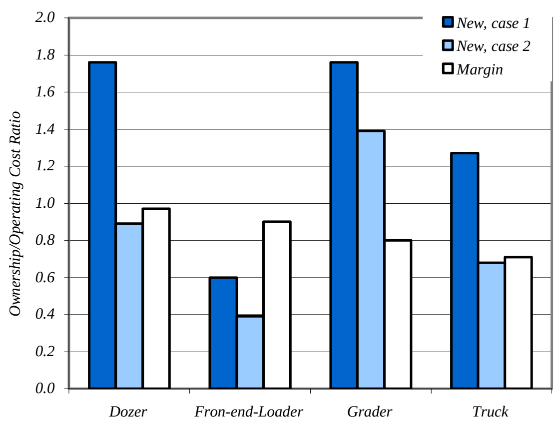


MARKET ANALYSIS-LOCAL PRICES

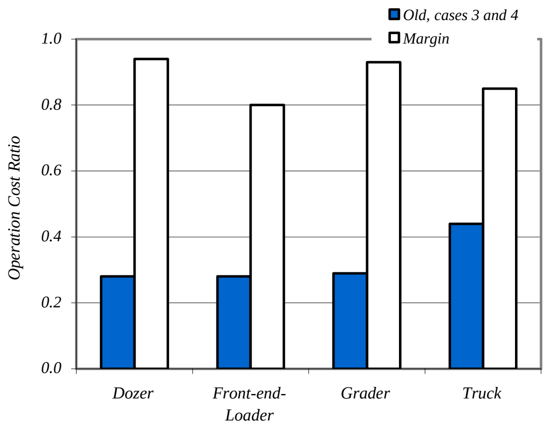
It is important that local market prices for construction cover the operation and ownership costs of equipment and provide a profit to the business. The pricing structure must allow the owner recovery of all cost so the replacement equipment can be purchased in the future. On the other hand, prices in northern Peru do not reflect the ownership duration. Both new and old equipment has similar prices. However, local specifications for jobs establish high requirements of machine, not only good operation conditions but date of manufacturing. The difference between the local market price for operating a machine and the machines operating cost can be termed "margin". This margin should equals or exceed ownership cost of a machine. If does not happen, local market prices will not support investment in new equipment.

Maximum margin possible has been plotted against ownership/operating costs ratio with cases 1 to 4 mentioned at the beginning for ownership cost analysis. Except for front-end-loader, the margin does not cover ownership costs of new equipment, Figure 8a. This is evidence of the influence of annual operating hours. The use of construction equipment is not intense in local market of northern Peru and that explains high ownership costs. The same type of comparison was made for old equipment. Second used equipment still in good condition has a grater margin and it covers operation and ownership costs, Figure 8b.

Figure 8 Margin and ownership cost ratio comparison in northern Peru market.



a) New equipment.



b) Used equipment.

In northern Peru, market conditions do not promote usage of equipment in construction projects. In general, equipment is intensively used for aggregate production (quarrying activities) much more than other job.

CONCLUSIONS

The demand for equipment is influenced by the policies of public institutions/agencies, which are main source of work for private contractors. At the same time the local market conditions in northern Peru dictate an average hourly rate for heavy equipment that is very low. This means that equipment owners purchasing and using new equipment cannot recover their expenses and there is no profit. Local market prices do not allow equipment replacement. Additionally, local market prices are not according to machine specifications and are less than new equipment costs.

The impact of extended machine usage clearly affects operating costs. Operating costs of old equipment is not greater than that of new units. This creates an impact on total costs and also on profit of the business.

It seems that favorable conditions and the very few working hours per year, as experienced in northern Peru, mitigates deterioration of the machine. Therefore in many cases a 15-year-old machine can be as efficient as a 5-years-old machine.

Better ways to increase profits in northern Peru is buying new equipment and keeping for at least 15 calendar years, and investing sufficient resources in a permanent maintenance program. Other options could be getting a big contract which characteristics should cover at least 15000 operating hours of each individual equipment. If is not expected big jobs frequently, buying used equipment in good conditions could be good enough for getting a good profitable business.

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Chinese Construction Firms in Reform

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Abstract
China's ongoing enterprise reform is considered a critical element for completing its transformation to a market-based socialist economy. The major objective of the reform is to transform traditional state-owned enterprises into modern corporate firms. This paper describes the evolution of Chinese construction firms from traditional state and collective ownership toward a mixed economy characterized by diversified ownership forms with a series of enterprise reforms in recent years. Based on the results from a questionnaire survey and a series of follow-up personal interviews, it has been determined that the majority of Chinese construction firms have already embraced commercial objectives and behavioral patterns similar to those of typical firms in developed market economies. Unfair competition was found to be a serious problem in the awarding of contracts. Major causes of this problem are clients' abnormal behavior in forcing the price down, asking contractors to pay for some or all of the construction costs, and delays in payment; these actions have led to severe financial difficulties for many Chinese firms and seriously disrupted the normal order of market stability.

Keywords
Chinese construction firms, enterprise reform, ownership form, firm objective, firm behavior.

INTRODUCTION

China's enterprise reform has essentially paralleled its economic reform because enterprise lies at the nexus of so many economic institutions. Under the former planned economic system, the state-owned enterprise (SOE), a dominant ownership form, was not really a business unit, but simply a producing unit (Ma 1999). The SOE's only objective was to satisfy the target plan (Ma 1999), and traditional SOEs obeyed and passively implemented the state's commands. SOEs did not have independent economic interests; they turned over all earnings to the state, the state was responsible for supply and sales, and all operational costs were reimbursed. Enterprise reform is considered a critical element for completing China's transformation to a market-based socialist economy. The specific objectives of the reform are to transform traditional SOEs into modern corporate firms, focus their activities, improve their economic performance, reduce their burdens on government

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finances, and enhance their ability to compete with foreign multinationals in international markets (OECD 2000), which is imperative due to China's entry into the World Trade Organization (WTO). The enterprise reform programs in the Chinese construction industry started by expanding managerial autonomy and providing incentives in contracts between managers of traditional state-owned construction firms and government supervisory agencies; resources still were allocated by the state with the goal of satisfying the state target plan (Wang 2001). These experiments in the 1980s and early 1990s led to considerable success in increasing construction productivity. However, they did not solve the basic problems of (a) traditional public firms' ambiguous enterprise property rights, (b) the combination of government control and enterprise operation, and (c) a heavy social welfare burden (Oi and Walder 1999). In addition, the earlier reforms brought about serious problems, such as the short-term rent-seeking behavior of insiders. Recent reforms have stressed a program of establishing a "modern enterprise system" in which the modalities of "corporatization" and "ownership diversification" have been used for restructuring state-owned construction firms, especially large and medium-sized ones (OECD 2000). The objectives of the "corporatization" program are (a) to transform state-owned construction companies into "modern corporate enterprises" with commercial objectives and clearly defined rights and obligations under the law and (b) to separate government ownership and regulatory functions by establishing the state as a shareholder with functions similar to those performed by private shareholders in other countries. "Ownership diversification" encourages shareholding among entities with various types of ownership. The Fifteenth Chinese Communist Party Congress in 1997, which decided to convert SOEs into shareholding companies, made it clear that China is a mixed economy in which a variety of ownership forms, including private ownership, co-exist. By promoting diversified forms of ownership, the authorities hope to sever more completely the direct ties between SOEs and their controlling authorities, as well as to encourage a more commercially oriented operation of corporatized firms by subjecting SOEs to the checks and balances of multiple shareholders.

The transformation of state-owned construction firms will lead to a situation where the majority of these firms are intermediate between public and private ownership. This study investigated the change in ownership of Chinese construction firms and the behavior that Chinese construction firms have adopted during this dynamic transformation period. Although the standard assumption in most economic models is that the primary objective of a firm is to maximize profits (Clarkson and Miller 1982), firms may have different objectives (Carlton and Perloff 1994), especially in complex institutions (Ma 1999). The results of a questionnaire survey and follow-up personal interviews provided the background data for assessing the primary objectives of various Chinese construction firms during the transition period and their strategic behavior to achieve the stated objectives; factors studied in this assessment are project procurement, competition methods, and unfair competition.

OWNERSHIP COMPOSITION OF CHINESE CONSTRUCTION FIRMS

Since the economic reforms began twenty years ago, and especially with the enterprise reform programs in recent years, ownership of Chinese construction firms has evolved from traditional state and collective ownership toward a mixed economy characterized by diversified ownership forms. Tables 1 and 2, which show the number of enterprises and employees of construction firms with a qualification class, indicate the changes of ownership forms in the industry during the period from 1996 to 2003 (data are taken from State Statistical Bureau 1997-2004: China Statistical Yearbook on Construction). According to the State Statistical Bureau (2004), state-owned enterprises (SOEs) refer to non-corporate economic units where the entire assets are owned by the state. Collective-owned enterprises are economic units where the assets are owned collectively and consist of urban collective-owned enterprises (UCEs) and township and village collective enterprises in rural areas. The shareholding category includes limited liability corporations and shareholding corporations. The private category includes private limited liability corporations, private shareholding corporations, private partnership enterprises, and private-funded enterprises.

Construction firms with a qualification class are a major force in the industry, representing 80% of the total firms in terms of both employees and gross output. A certain qualification class is required for a firm to construct almost all large and medium projects in China.

Table 1. Number of Enterprises by Ownership Forms (1996-2003)

Year	Total	SOE		UCE		Shareholding		Private	
		Number	%	Number	%	Number	%	Number	%
1996	41,364	9,109	22.	29,044	70.2	1,601	3.9	535	1.3
1997	44,017	9,650	21.	29,872	67.9	2,245	5.1	810	1.8
1998	45,634	9,458	20.	26,818	58.8	5,741	12.6	2,416	5.3
2000	47,518	9,030	19.	22,770	47.9	9,736	20.5	4,872	10.3
2001	45,893	8,264	18.	17,204	37.5	11,956	26.1	7,534	16.4
2003	48,688	6,638	13.	10,425	21.4	17,230	35.4	13,732	28.2

Table 2. Number of Employees (10,000) by Ownership Forms (1996-2003)

Year	Total	SOE		UCE		Shareholding		Private	
		Number	%	Number	%	Number	%	Number	%
1996	2,121.	855.9	40.3	1,171.4	55.2	60.5	2.9	8.64	0.4
1997	2,101.	828.6	39.4	1,148.2	54.6	83.7	4.0	12.29	0.6
1998	2,085.	765.3	36.7	1,008.9	48.4	255.5	12.3	49.18	2.4
2000	2,105.	689.5	32.8	828.2	39.3	460.1	21.9	109.94	5.2
2001	2,283.	649.9	28.5	694.6	30.4	703.1	30.8	243.41	10.7
2003	2,414.	524.3	21.7	505.6	20.9	1,014.6	42.0	363.85	

Tables 1 and 2 clearly illustrate the increasing decline of traditional SOEs and UCEs and the rapid growth of new-form firms in the industry. In 1996, almost all construction firms with a qualification class were either state-owned or urban collective-owned enterprises. As a result of the current enterprise reforms, many of the traditional construction enterprises have been transformed into the ownership forms that are intermediate between public and private ownership, shareholding in particular, with UCEs being restructured faster than SOEs. Shareholding firms have been developing rapidly, especially since 1997. While in 1996 they accounted for very few of the total firms in the industry, by 2003 they grew to 35.4% of the total enterprises and 42.0% of the total employees. In China, both limited liability corporations and shareholding corporations are recognized as components of a "modern corporate enterprise" system, which is the transformation direction of the majority of SOEs and UCEs. The conversion of SOEs and UCEs to limited liability corporations and shareholding corporations has stimulated the rapid growth of the shareholding economy. There were few private firms in 1996, but the role of the private sector has been progressively upgraded in the official reform architecture. Government encouragement and concrete measures adopted by the local governments have created a favorable environment for the rapid development of the private sector.

Based on the foregoing analyses, it is seen that the industry has become diversified in these years and the role of state-owned enterprises has progressively declined. The increasing growth of joint public-private and private firms has accounted for the greatest source of change in the ownership structure of the Chinese construction industry.

SURVEY

A questionnaire survey of many Chinese construction firms was undertaken during the period from April to September 2002 to gather background information for a subsequent series of in-depth interviews which were conducted from July to September 2002. The questionnaire was designed to identify and examine a firm's primary objectives, behavior in project procurement, competition methods, and unfair competitive behavior. The objectives and various strategies included in the questionnaire were chosen from the literature and from personal interviews and discussions with experts holding senior managerial positions in construction firms and with faculty from academic institutions. This questionnaire was distributed to 950 construction firms, and 139 replies were received from firms based in many major cities. For purposes of this survey, firm directors or decision-makers were asked to complete the questionnaire or to closely oversee its completion; in fact, more than half of the respondents (57%) held senior positions, such as general manager, department manager, general engineer, and general economist. In addition, the majority of all respondents had more than twenty years work experience in construction, and one-third had more than thirty years work experience. Although the response rate (15%) was lower than desired, the reliability of the results is considered to be high due to the high qualifications of the respondents. This high reliability was confirmed by twenty-six subsequent personal interviews with people currently in senior managerial positions. The firms interviewed were determined by examining the responses in the returned questionnaires and selecting those companies that offered the greatest potential for contributing to this study; the interviewees included nine SOEs, one UCE, eleven shareholding firms, and five private firms.

OBJECTIVES OF CHINESE CONSTRUCTION FIRMS

To examine the primary objectives of Chinese construction firms during this dynamic transformation period, the questionnaire asked respondents to rank order their firm's top three objectives from among eight choices provided, and the results are summarized in Table 3. "Maximizing profit", "achieving the projected annual output", and "increasing market share" emerged as the first, second, and third objectives of Chinese construction firms. It is notable that profit maximization, the goal of a typical firm in a developed market economy, is regarded as the most important objective of Chinese construction firms, which are still undergoing transformation. From the survey responses, it is evident that the objectives of Chinese construction firms have changed greatly during the enterprise reforms from meeting the state target to achieving commercial objectives. Accordingly, China's enterprise reforms have obviously made great progress. Notwithstanding the relatively strong emphasis on the objectives discussed above, the distribution among the remaining objectives indicates that there is reasonable diversity among firms during this dynamic transformation period.

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Table 3. Top Three Objectives of Chinese Construction Firms

Objective	First objective		Second objective		Third objective	
	Number	%	Number	%	Number	%
Achieving the projected annual output	28	21.2	24	18.2	11	8.4
Maximizing profit	50	37.9	20	15.2	13	9.9
Increasing market share	18	13.6	23	17.4	36	27.5
Growth of the firm	12	9.1	13	9.8	19	14.5
Increasing employee income	2	1.5	15	11.4	17	13.0
Improving the firm's reputation	15	11.4	22	16.7	19	14.5
Improving the firm's operating	3	2.3	15	11.4	9	6.9
Contributing to society	4	3.0	0	0.0	7	5.3
Total number of firms	132	100.0	132	100.0	131	100.0

RELATIONSHIP BETWEEN OWNERSHIP FORM AND FIRM OBJECTIVE

Firms with different ownership forms will generally have different objectives. As discussed previously, one result of the transformation to a market economy is the diversity of ownership forms in the current Chinese construction industry, ranging from traditional state-owned enterprises to modern shareholding firms. Among the responding firms in the survey, there were 68 SOEs, 9 UCEs, 45 shareholding firms, and 10 private firms. Table 4 relates the objectives of these firms with the different ownership forms. Since many UCEs and private firms were reluctant to participate in this survey, the number of such respondents is relatively small and the reliability of the relationship between these ownership forms and firm objectives should be viewed accordingly.

Table 4. Ownership Forms and Firm Objectives

Objective order	Ownership form	Percentage chosen (%)							
		Achieving projected annual output	Maximizing profit	Increasing market share	Growth of the firm	Increasing employee income	Improving the firm's reputation	Improving the firm's operating efficiency	Contributing to society
First objective	SOE	20.6	44.1	11.8	5.9	1.5	8.8	2.9	4.4
	UCE	11.1	22.2	33.3	11.1	0.0	22.2	0.0	0.0
	Shareholding	26.7	35.6	13.3	8.9	2.2	11.1	0.0	2.2
	Private	10.0	20.0	10.0	30.0	0.0	20.0	10.0	0.0
Second objective	SOE	22.1	7.4	20.6	14.7	10.3	13.2	11.8	0.0
	UCE	0.0	11.1	0.0	0.0	33.3	22.2	33.3	0.0
	Shareholding	15.6	22.2	17.8	6.7	11.1	17.8	8.9	0.0
	Private	20.0	40.0	10.0	0.0	0.0	30.0	0.0	0.0
Third objective	SOE	7.5	11.9	25.4	17.9	10.4	14.9	4.5	7.5
	UCE	22.2	11.1	11.1	0.0	0.0	22.2	11.1	22.2
	Shareholding	8.9	6.7	28.9	13.3	15.6	15.6	11.1	0.0
	Private	0.0	10.0	50.0	10.0	30.0	0.0	0.0	0.0

The most important message conveyed by Table 4 is that ownership form does affect firm objectives. The predominant first objective for SOEs is "maximizing profit." It is notable that 44.1% of the 68 SOEs, which is the traditional ownership form in China, selected "maximizing profit" as their most important objective. The most common second objective for SOEs is "achieving the projected annual output". The third objective was "increasing market share". These survey results show rather clearly that current enterprise reforms have made important progress toward encouraging SOEs to be more commercially oriented.

In contrast, the objectives of UCEs, another traditional ownership form, differ from those of SOEs. Their most common first objective is "increasing market share." However, "increasing employee income" and "improving the firm's operating efficiency" are the predominant second objectives, and "achieving projected annual output", "improving the firm's reputation", and "contributing to society" are the third objectives. These results show that "increasing employee income" is an important objective for UCEs and that some UCEs have noncommercial objectives, such as "contributing to society." UCEs are generally smaller, more poorly equipped, and less capitalized than SOEs, and this leads to their competitive disadvantage in the marketplace. Therefore, improving market share, operating efficiency, and the firm's reputation are considered important objectives by the UCEs.

For shareholding firms "maximizing profit" is extremely important. Table 4 shows that "maximizing profit" is either the first or second predominant objective for almost 60% of the shareholding firms, and it is also the same as the primary objective of SOEs. This is because current enterprise reforms encourage SOEs to convert into shareholding firms with diversified shareholders and a more commercial orientation, and, as a consequence, many shareholding firms are transformed SOEs.

The most common first objective for private firms is "growth of the firm"; this is probably because private ownership is in the beginning stages of growth in China and therefore private firms put much more emphasis on improving the firm's growth. "Maximizing profit" and "increasing market share" are the second and third most common objectives for private firms. No private firm indicated that "contributing to society" is an important objective. In general, private firms in the Chinese construction industry have objectives similar to those of firms in developed market economies.

Since information obtained from personal interviews is considered to have greater validity than that obtained from a survey, considerable emphasis was placed on the interviews. When the personal interviews were conducted, a majority of the firms chose "maximizing profit" as their first objective, irrespective of the ownership form; however, this objective seemed to be more like a slogan than an actual business goal. As examples, one interviewee stated "Profit maximization should be the firm's objective in a market economy"; another person pointed out that "it is only a stated objective"; and yet another explained that, when making the change to a real profit-motivated firm, "it's easier said than done." During this transformation to a market economy, concepts commonly used in market-oriented countries have been injected by the government into the entire Chinese society, particularly among the top managers in state sector firms who are usually appointed by the government. Notwithstanding these stated ideals, real steps toward achieving these goals are lagging. The interviews confirm the importance of still "achieving the projected annual output", which is considered a "concrete" objective. In fact, it is the firm-projected annual output that heavily influences its strategies. The majority of the firms considered output to be the best indicator of a firm's capability; therefore, great effort was directed toward achieving the stated output value, even at the expense of profit.

PROJECT PROCUREMENT

Under the former system, the Chinese construction industry was considered a non-profit sector in the national economy. Construction projects were assigned to construction firms and carried out on the basis of a standard cost concept (Chan et al 1999). In keeping with the reform toward a market-oriented economy, a competitive bidding system was introduced into the Chinese construction industry in the early 1980s to supplement and gradually replace the traditional assignment system (Shen and Song 1998). The Bidding Law of the People's Republic of China, published in 1999, stipulates that a project funded by the state or by international financial institutions is required to undergo a bidding process. Table 5 shows how Chinese construction firms currently obtain their contracts.

The most common method for Chinese construction firms to obtain contracts is clearly "competitive bidding." For 69.2% of 133 respondents, it is the primary (but not necessarily the only) method, and for another 26.3% of the firms, it is used in conjunction with one or more other methods to procure projects. Administrative assignment is uncommon; no firm obtained contracts only by government assignment, and there were only 8 firms out of 133 that obtained some of their projects through assignment. These results affirm the widespread use of "competitive bidding" as the primary method by which Chinese construction firms obtain contracts. On the other hand, 29.4% of 133 firms obtained projects by "relationships" or methods including "relationships" ("relationships" refer to taking advantage of personal contacts with individuals responsible for project procurements or assignments). These results suggest that personal connections are very important in project procurement in China.

The interviews confirmed that most projects were awarded through competitive bidding. However, it is very important to point out that most of the interviewed firms also expressed the importance of relationships in bidding. In many cases firms stated that they would not bid for projects unless they already had some connections to the project client, because "it is impossible to be awarded a contract without relationships, even though you are the best in the bid." One firm made it clear that more than 90% of their awarded projects relied on relationships. Alternatively, many firms stressed that, although relationships are important, firms should be good enough in every aspect among competitors to win a contract solely on their own merits. In reality, contractors can submit their bids only after they have passed the client's bidder qualification examination, and the project is often awarded to the firm that gains the highest score among competitors in the final bid evaluation. The factors evaluated include bid price, construction plan, reputation, experience, project professionals, and so forth. According to the interviews, relationships can help a firm pass the bidder qualification examination and obtain high scores on various subjective items, such as reputation, in the bid evaluation. However, a good relationship is no guarantee that the contact will be awarded. Although many relationships are "initiated" by construction firms, the interviews revealed that it is the clients' expectation of favors in return, quid pro quo deals, and other special arrangements that "cultivate" the importance of relationships in winning contracts. Currently, many projects, especially large and medium ones, are funded by the state or state-related organizations. Government officials, project clients, and their representatives who have power in project procurement often seek favors for their own benefit. Even private project developers want some "promises" from firms before bidding starts. Although the law requires that projects be awarded through a competitive bidding process, many "deals", commonly called "dark room operations", are still commonplace.

Table 5. Common Method(s) Used to Obtain Contracts

	Methods to obtain contracts	Number	Percentage (%)
1	Assignment by government	0	0.0
2	Relationships	5	3.8
3	Competitive bidding	92	69.2
4	1 and 3	1	0.7
5	2 and 3	27	20.3
6	1,2, and 3	7	5.3
7	Other	1	0.7
	Total number of firms	133	100.0

COMPETITION METHODS

Various methods are used by firms to better their positions in market competition. Table 6 shows the competition methods most commonly used by Chinese construction firms. "Improving construction quality" was selected as the most common first competition method; and 114 of 139 respondents selected it as one of the top three methods, indicating the significance of quality issues for Chinese firms. The intense competition in the market forces firms to develop a reputation for good quality to distinguish their products from those of their competitors. "Cutting price" followed "improving construction quality" as the second most common first method; it was also chosen as the most common third method. Of all 139 respondents, 82 selected it as one of the top three methods, showing that the majority of firms use it as a common means of competition. The results indicate fierce competition in the Chinese construction market, which significantly limits firms' profitability. "Shortening construction time" was chosen as the most common second method, and

61 of all 139 respondents selected it as one of the top three competition methods. Construction delivery time has become increasingly important these days due to the development of the market system and more projects by private developers.

This study also revealed that "paying for construction costs" is a common competition strategy. This phenomenon is indicative of an intense competition among firms on one hand and an unfair and underdeveloped market on the other hand. Currently, many clients do not have sufficient funds to finance their projects, and they take advantage of the prevailing buyers' market and undeveloped market mechanism by asking contractors to pay for some or all of the construction costs until the project becomes profitable. Consequently, contractors often face serious arrears in payments. Without an advance and on-time payment, many contractors must use their own money or borrow money from the banking system or other sources to support a project. This creates a situation where the clients owe money to the contractors, and the contractors owe money to the banks or other sources. Such a debt situation is considered one of the critical problems that is seriously plaguing the industry at present.

Table 6. Common Competition Methods

Strategy	First method		Second method		Third method	
	Number	%	Number	%	Number	%
Cutting price	44	31.7	15	10.8	23	16.5
Improving construction quality	58	41.7	37	26.6	19	13.7
Shortening construction time	1	0.7	42	30.2	18	12.9
Developing relationships	8	5.8	11	7.9	11	7.9
Advertising	0	0.0	0	0.0	2	1.4
Paying for construction costs	6	4.3	12	8.6	18	12.9
Technological innovation	10	7.2	9	6.5	15	10.8
Marketing	7	5.0	3	2.2	2	1.4
Improving operation efficiency	1	0.7	0	0.0	10	7.2
Improving project management	4	2.9	10	7.2	21	15.1
Total number of firms	139	100.0	139	100.0	139	100.0

The foregoing responses reveal that Chinese construction firms are facing a very difficult period with intense competition and an underdeveloped market. On one hand, they improve the quality of their work and delivery time to differentiate themselves and gain a competitive advantage over competitors, while, on the other hand, they cut their price and pay for construction costs to secure projects.

The in-depth interviews indicated a different emphasis in competitive strategies between firms with different ownership forms. A majority of SOEs regarded "cutting price" as their primary means of competition. SOEs often suffer heavy burdens, such as high operating costs and debt service. Compared to other ownership forms, SOEs stated that "we do not have advantages in price competition because our overhead is too high." For the only UCE interviewed, "improving construction quality" was the firm's first means of competition; this is the same result identified by the UCE responses in the questionnaire. Compared with SOEs, UCEs are smaller, and they are often less capable in terms of the quality of their management staff, the amount of available capital, technology, and other indicators of corporate quality strength. In addition, they generally have a poor construction quality record, which they are endeavoring to improve so that they can compete with other firms in the market. Many shareholding firms selected "cutting price" as the first means of competition, and some considered "improving construction quality" as the first or second means of competition. All private firms considered "improving construction quality" as their first or second means of competition.

UNFAIR COMPETITION

Unfair competition is currently quite common in China and is particularly serious in the construction market. This survey investigated the most common forms of unfair competition in the Chinese construction market, and asked respondents to identify and rank the three most common unfair practices in their experience; the results are given in Table 7. "Client forcing the price down" emerged as most common unfair competitive behavior in the market. Among the second selections, "paying for construction costs" was the most common form of unfair competition; and "arrears in project payment" and "playing favorites in bidding" were identified as the most common forms from among the third selections. Meanwhile, "arrears in project payment" was also the second most common unfair practice among the second selections. The results suggest that clients' abnormal behavior has caused most unfair competitive activities in the industry. Clients often take advantage of a buyers' market and undeveloped market mechanisms to increase their own benefit at the expense of construction firms. By virtue of their bargaining power in the bidding process, they often force down the price and in many cases they make it known in advance what price they are willing to pay and ask for bids below that figure. Negotiation after the bid to get a contract price lower than the bid price is very common. Furthermore, clients ask contractors to pay for construction costs because of their shortage of funds, largely consuming the contractors' working capital, which is very low in the first place. After construction, contractors usually face serious arrears in payments. In addition, although the majority of projects were awarded through competitive bidding, "playing favorites in bidding" often occurred in the bidding process, especially for the state-funded projects.

Table 7. Most Common Forms of Unfair Competitive Behavior

Forms	First selection		Second selection		Third selection	
	Number	%	Number	%	Number	%
Client forcing the price down	54	39.4	20	14.6	21	15.3
Client asking for off-the-book	2	1.5	8	5.8	6	4.4
Paying for construction costs	23	16.8	47	34.3	20	14.6
Taking advantage of	10	7.3	8	5.8	12	8.8
Playing favorites in bidding	18	13.1	13	9.5	26	18.9
Arrears in project payment	15	10.9	28	20.4	26	18.9
Bribery	1	0.7	2	1.5	3	2.2
Harsh and unfair contracts	12	8.8	6	4.4	18	13.1
Local or departmental	2	1.5	5	3.6	5	3.6
Total number of firms	137	100.0	137	100.0	137	100.0

The survey also showed that "harsh and unfair contracts" and "taking advantage of relationships" are common in the market. Due to their inferior position in bidding, contractors who are awarded projects often have to accept unreasonable requirements and harsh terms. In addition, personal relationships are very important in securing a project.

When the issue of unfair competition was discussed, all interviewees considered it to be the most serious problem affecting the order of the market competition and firm performance. Most of them believed that it is the "client" who has caused the unfair competition. According to one firm "We are passive; we have to do what clients want us to do. For example, paying for construction costs is a prerequisite to enter into the bid." As the questionnaire results showed, "client forcing the price down," "paying for construction costs," and "arrears in project payment" were considered the most common unfair competitive behaviors in the market. In some cases, firms made it clear that "client forcing the price down," "paying for construction costs," and "harsh and unfair contracts" were imposed concurrently. In a few cases, firms opined that all of the unfair competition phenomena listed in the questionnaire are very serious. One well-known contractor stated that the clients for all of its projects required payment for construction costs. The only UCE interviewed said that it could no longer afford to pay for clients' construction costs.

CONCLUSIONS

China's enterprise reform is considered a critical element for completing its transformation to a market-based socialist economy. Since the economic reforms that began twenty years ago, and especially with the enterprise reforms in recent years, ownership of Chinese construction firms has evolved from traditional state and collective ownership toward a mixed economy characterized by diversified ownership forms. A questionnaire survey and personal interviews were conducted in major cities in China to investigate the primary objectives of various Chinese construction firms and the strategic behavior that they have adopted to achieve the stated objectives during this dynamic transformation period.

A synthesis of information gathered from an initial survey and a subsequent series of largely confirming personal interviews suggests that China's enterprise reforms have made great progress. It has been determined that the majority of Chinese construction firms have commercial objectives and behavior similar to those of typical firms in developed market economies. Chinese construction firms have changed from satisfying only the state target to achieving normal commercial objectives, such as profit maximization, a firm-projected annual output, and increased market share. Ownership form was found to exert some influence on the primary objectives of a firm. Competitive bidding, a common international practice, is now the primary method by which Chinese construction firms obtain contracts. Improving construction quality and price-cutting were found to be the most common competitive methods.

However, the legal system and relevant facilities to control the market, as well as the people's consciousness of the market economy, are still evolving, and this study indicated that unfair competition is quite serious in the construction market. There were many "deals" aside from competitive bidding. Clients take advantage of the buyers' market and the poorly developed market mechanisms to increase their own benefit at the expense of construction firms. Their abnormal behavior, especially forcing the price down, asking contractors to pay for construction costs, and delays in payment, has caused severe financial difficulties to Chinese firms and seriously disrupted the normal order of market stability.

Eliminado: *Countries*

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Integrating CSR, Ethics and Sustainable Development Principles into the Construction Industry

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Abstract
The Agenda 21 for sustainable construction in developing countries (CIB, 2002) was formulated specially for the building industry to go towards sustainable development on its environmental, social, economical and cultural dimensions. The transition to sustainable development requires the focus on Corporate Social Responsibility (CSR), integrating principles of ethics and responsibility into the daily actions and decisions of both individuals and companies. This study attempts to analyze CSR objectives and practices in the construction industry of the State of Bahia, Brazil, while bridging business ethics to CSR and, at the same time, suggesting a conceptual CSR model to identify and analyze social responsible practices of this sector. The findings revealed that making social and environmental aspects count in business and making this shift towards a more sustainable paradigm depend on two concepts: a) a sustainable development, which sets out the goals that companies should focus on and b) CSR that contributes with arguments as to why business should work towards these goals. However, to achieve these concepts will ultimately depend on ethical values of the top management to become more responsive to social and environmental issues, and learn to manage business within a CSR culture.

Keywords
Corporate social responsibility, sustainable development, business ethics, construction industry.

INTRODUCTION

One of the main challenges to business is to strike a balance between economic activity and what is socially and ecologically sustainable. Waste, pollution, poverty, unemployment, and other problems, are the side-effects that make the society and the environment pay a price for rising populations, urbanizations and unsustainable consumption and production of more goods and services. In addition, social and environmental impacts extend beyond national boundaries and the protection involving aspects such as pollution control, waste minimization, natural resources conservation, job and equal employment opportunity, has became a high priority for all nations. Business leaders and managers are being challenged by the need to integrate ecological thinking into the decision making. Today, companies are learning how to adjust their products, manufacturing processes, purchasing activities, and business strategies to the need for sustainable economic, social and environmental practices express (LEÃO-AGUIAR *et al*., 2004).

This work is part of a MSc dissertation project in course, in the Post-Graduate Course on Urban Environmental Engineering School at Federal University of Bahia. The project aims to make a contribution to the companies in the construction industry in the State of Bahia, come to integrate in its operations, the economic, social and environmental impacts, based on the triple bottom line – TBL (economic efficiency, environmental protection and social justice). This means business goals should not only be related to the profits, classic concept of the Capitalism, but also with a concern with the planet and the people. The research involves four stages and the main goals are: 1) to evaluate how top management, in the construction industry, understands the concept of CSR and how they integrate social responsibility into their activities; 2) to identify the main practices of CSR of the sector; and 3) to analyze not only the motivations but of the barriers faced by of the sector to adopt socially responsible strategies and actions.

In the first stage, an exploratory study was undertaken, based on literature review, and analysis of documents related to thinking and practices of CSR by the industry in general and by the construction industry in particular. Through a critical analysis of these data, especially studying the existing theoretical models of CSR, it was proposed a new model that contemplated the most recent discussions about a new form of business management based on triple bottom line (TBL): guided for objectives related not only with the profits, classic concept of the Capitalism, but also with a concern with the planet and the people. Because of the understanding that the social system is dynamic and a nonlinear net, it was used the concept *kaizen* to build the structure for the new CSR model based in the ideas of the sustainable development. According to Imai (1988), *kaizen* is a Japanese philosophy for continuous improvement of all members of the organizations. In the second stage, an unstructured interview was applied to representatives of the two major associate institutions of the construction sector: the Union of the Civil Construction of the State of Bahia (SINDUSCON-BA) and the Association of the Top Management of the Construction Industry and the Real State of Bahia (ADEMI-BA).The main goal here was to explore preliminary information about CSR in the sector.

At this moment, this project is in the third stage, which the goal is to analyze the data from the two surveys applied to all sectors of the State by the Federation of the Industries of the State of Bahia (FIEB). The first survey, held from 22-October-2003 till 20-February-2004, was about environmental management. The FIEB contacted 61 companies of the construction sector and 44 answered the questionnaire. The second survey, which ended in April of 2005, was about the practices of CSR, not taking into account the environmental issues of the first survey. In this second survey, 41 firms form the construction industry answered the questionnaires. Currently, 105 construction companies are registered in the SINDUSCON-BA and 78 companies in the ADEMI-BA. The main goal of this stage and paper is to explore the interface between CSR, ethics, sustainable development and business excellence, and to examine issues associated to social and environmental practices in the daily operations of the firms.

In the final stage, to further and to deepen the understanding of the CSR in the sector, three study cases will be undertaken in companies with different scales, in order to triangulate the data of the other stages. The evidences of the case studies will come from documents, interviews, and participant observation. At the end of the project, it will be possible to draw a picture of the CSR in the construction industry of the State of Bahia, the companies' CSR practices and perceptions of the managers, the real reasons for which the companies embrace or not this concept, and which are the achievements and the barriers during this process of changing the route to a New Age, where the global economy is compatible with social justice and equity, and with environmental protection.

WHY SHOULD BUSINESS BE ETHICAL?

Every business has complex relationships with many people, groups, and organizations in society. The stakeholders are those people and groups that affect, or can be affected by an organization's decisions, policies, and operations. The relationship between companies and their stakeholders is changing over the years: customers, suppliers, employees, owners, creditors, local communities, and others, have a stake in the business, and their support con be critical to its success or failure. Ethics is a concept of right and wrong conduct. Ethical principles, according to Srour (1998), are guides to moral behavior. Ethical ideas are present in all societies, organizations and individuals, although they may very greatly form one to another. Business ethics, argument Steiner and Steiner (2003) is the application of general ethical ideas to business behavior. Ethical business behavior, according to Post *et al*. (2002), is expected by the public, prevents harm to society, improves profitability, fosters business relations and employee productivity, reduces criminal penalties, protects business employees from harmful actions by the employer, and allows people in business to act consistently with their personal ethical beliefs.

Managers are one of the keys to whether a company will act ethically or not. The values held by the managers, especially the top-level, can serve as models for the rest of the organization. Personal values and moral character, suggests Hemingham and Maclagan (2004), also play key roles in improving a company's ethical performance. However, these characteristics can be affected by a company's culture. According to Maximiano (2004), corporate culture is a blend of ideas, customs, traditional, practices, company values, and shared meanings that help define normal behavior for all who works in a company. Companies, suggest Post *et al*. (2002), improve their ethical performance by creating a value-based ethics program that relies on top management leadership and organizational safeguards, such as codes of ethics, ethics committees, ethics training programs, ethics audits and corporate ethics awards. Business must find ways to balance and integrate two demands: high economic performance and high ethical standards. Ethical behavior, according to Steiner and Steiner (2003), is a key aspect to corporate social performance to maintain public support and credibility (business legitimacy). When a company acts ethically towards its stakeholders, it improves its contribution to society. When a company fails to act ethically, however, it faces the risk of loosing the public support needed to be both credible and successful. Ethical expectations are a vital part of the business environment.

WHAT DOES THE IDEA OF SUSTAINABLE DEVELOPMENT MEANS FOR BUSINESS?

Sustainable development is a broad, dialectical concept that balances the need of economic growth with social equity and environmental protection. The term was first popularized in 1987, in Our Common Future, published by the World Commission for Environment and Development (WCED). The WCED described sustainable development as development that meets the needs of present generations without compromising the ability of future generations to meet their needs. The WCED recognized that the achievement of sustainable development could not simply be left to government regulators and policy makers. It recognized that business has a significant role to play. CSR practices mean that the companies voluntary move beyond the minimum legal standards established by social and environmental regulations, by improving their performance in all areas of their operations. The value and the importance of sustainable development to long-term business success, according to Zhao (2004), have been widely recognized by many companies, in particular by larger companies. However, according this author, only a few of them have managed to integrate sustainable development effectively into their daily operations and business practices. Most of today's business excellence models focus predominantly on a single bottom line of financial results rather than also attending to the social and environmental impact of businesses (triple bottom line).

A NEW THEORETICAL MODEL FOR CSR

Like sustainable development, CSR is also a broad concept, and in the most general terms, it deals with the role of business in society. According to the International Institute for Sustainable Development (IISD, 2004) no universally accepted definition of CSR exists. The World Business Council for Sustainable Development (WBCSD), the Commission of the European Communities (COM), the Ethos Institute and the Brazilian Association of Technical Standards (ABNT) considers CSR as the commitment of business to integrate social and environmental issues in their daily operations and their interaction with the stakeholders, in voluntary bases. CSR, suggests Carroll (1999), means that a corporation should be held accountable for any of its actions that effect people, the communities and the environment. However, defends Handy (2003), being socially responsible does not mean that a company must abandon its other primary missions. The challenge of business is to blend the responsibilities: economic, legal, social and environmental, into comprehensive corporate strategy, while not losing sight of any of its obligations. Thus, according to Martin (2003), having multiple and sometimes competing responsibilities does not mean that socially responsible firms cannot be as profitable as others less responsible. There are strong arguments, according to Post *et al*. (2002), on both sides of the debate about business social responsibility. Many people believe that both business and society gain when firms actively strive to be socially responsible. Others are doubtful, saying that taking social tasks weakens business competitive strength. (Table 1)

Table 1 – The pros and cons of CSR

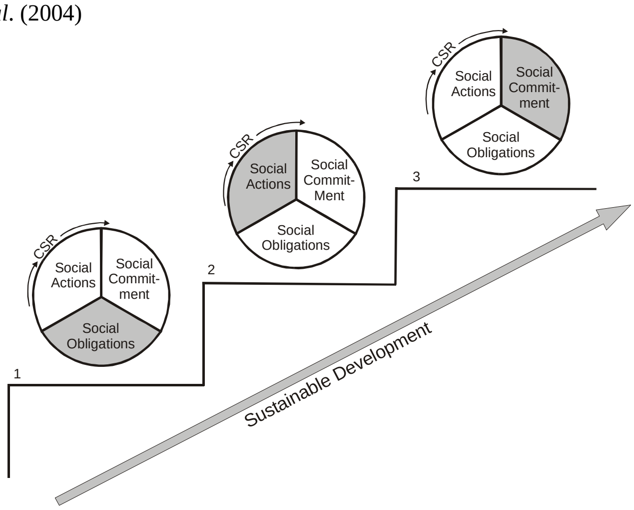
Arguments for CSR	**Arguments against CSR**
• Balances corporate power with responsibility.	• Lowers economic efficiency and profit.
• Discourages government regulation.	• Imposes unequal costs among competitors.
• Promotes long-term profits to business.	• Imposes hidden costs passed on to stakeholders.
• Responds to changing stakeholders' demands.	• Requires social skills business may lack.
• Corrects social problems caused by business.	• Places responsibility on business rather than individuals.

Source: Post *et al*. (2002)

Since the Earth Summit, a growing number of companies now acknowledge the importance to base CSR in the principles of sustainable development, along with the principles of ethics. However, companies are faced with the problem of how to put this into practice. Recently various theoretical frameworks have been developed to assist companies in their efforts to implement CSR. For Cramer (2004), the journey to CSR is not clear-cut; it is a searching process in which leaders have to develop their own identity based on finding a responsible balance between people, planet and profit while taking account of what the outside world requires from them.

Leão-Aguiar *et al*. (2004) propose a theoretical model for CSR elaborated from the understanding of the concept of social responsibility associated to the commitment with ethics and sustainable development. The companies while adopting this model of CSR, certainly will have a larger democratic participation of the diverse groups of interest, in short terms far from the simple financial return. This model holds a strong ideological dimension, bringing significant positive consequences for all involved actors. Inclusively, the proposal of the model is to dislocate the debates on CSR of the management level to an institutional order, and according to Kreitlon (2004), would be, without a doubt, effectively a radical and an ethical move. For this author, although the CSR definitions vary in accordance with historical and social context, and above all, with the interests of the social groups that formulate them, the application of the CSR concept represents a field of strategies and creative solutions for the companies and the environment. (Fig. 1)

Fig. 1 - Leão-Aguiar *et al*. CSR model (2004)
Source: Leão-Aguiar *et al*. (2004)



Companies do not become socially responsive overnight. The process, according to Sethi (1975), takes time: new attitudes have to be developed, new routines learned, and new policies and action programs designed. In the first stage of this model, companies become aware that they should respond to emerging issues, concerns or social and environmental trends, attending to the legal and the economic requirements. In this initial stage, programs can be required by government regulations or by agreements negotiated with stakeholders such as union contracts. While stepping forward, going to the second stage, companies deal with other elements of social responsibility related to the market and voluntary actions. The voluntary actions go beyond regulatory mandates in areas such as minority advancement, worker safety, or pollution control, and also to programs that respond to a national consensus, such as contributing to charity or improving adult literacy. The cycle begins to move with the stakeholders' pressure, in a continuous improvement. In the third stage, social and environmental practices may turn to commitments, going beyond philanthropy and superficial and disarticulated business practices. The companies, in this stage, will take into account ethical challenges to balance in equal terms: economic, social and environmental responsibilities (triple bottom line). According to Pena (2002), this dimension of CSR as a social commitment, gradually extends the stakeholders' involvement towards the idea of a sustainable society. This can include the participation of business in formulating better public policies.

CSR AND THE CONSTRUCTION INDUSTRY OF BAHIA

The construction industry impacts intensively the society and the environment. Buildings and structures consume large amounts of raw materials, energy and water in their operations, and they generate a great volume of waste and pollution. In developing countries, this industry also has a generally poor record of employment and under-performs on issues such as gender and ethnics. Groups such as women and ethnic minorities are usually under-employed. The construction industry of Brazil, according to Furtado (2002), operates in the limits to attend governments' regulations. The problems of the construction sector in the State of Bahia are similar to the Brazilian's industry: low human productivity, low level of industrialization, high material consumption rates, high material wastage, unfair labor practices and low quality products.
The Industries´ Federation of the State of Bahia (FIEB) undertook a survey on Corporate Social Responsibility during the period between December 20 of 2004 and April 30 of 2005. It was applied a questionnaire to 163 companies of several industrial sectors of the State, being 41 companies from the construction industry. The main objective of this survey was to know how CSR is introduced in the agendas of the industries, as also reveal opportunities to introduce CSR in the companies. The companies were classified by the number of employees, according to the Brazilian Service to Aid Small Companies (SESI) and their annual invoice. According to the sample of the construction industry (41): 41.5% are small companies (20-99 employees), 41.5% are medium companies (100-499 employees), and 17.1% are large companies (more than 500 employees); and 78% of the companies have an annual invoice between R$ 1,200,001.00 and R$ 60,000,000.00[1].

The survey revealed that 55% of the construction firms do not have strategies or a specific policy for CSR, and 55% of those firms believe that CSR is most related to paying taxes and job generation. Even though 46.4% of the companies believe that their ethical commitments are only for the fulfillment of the law, 95% of them believe having a Code of Ethics helps disseminate similar social responsible attitudes, and 92.5% understand that the Code of Ethics contributes positively to the business image. Although the commitment with social and environmental practices is still in a low level, 80.5% of the firms understand that a social responsible company can maximize their profits while fulfilling their social obligations. Social Reporting is not a common practice in the construction industry of Bahia, but 95% of the firms understand that this practice help evaluate the social and environmental impacts in society and also helps making plans for improvements. The are many objectives of the construction companies to adopt CSR, but mostly are issues related directly to the workplace, the business and the image of the company. The findings show that CSR can be found to be multifaceted, covering areas such as employee welfare, consumer and environmental issues, corporate sustainability and philanthropy. (Tables 2 and 3)

Most of the social practices in this sector, according to the survey, are related to the employees' pressures through labor unions and agreements on the areas of basic needs of the individual: nourishment, health and education. According to the results, 84.6% of the companies report periodically to the labor unions and 90.2% allow the unions to visit the workplace. Other practices such as recruiting and discharge policies, equal employment for individuals with disabilities, elder, and former prisoners, as also mechanisms to prevent sexual and racial harassment, are not common in the construction industry. One of the great problems that leaders from the construction industry affirmed in earlier interviewees is the existence of informal workers, which they believe corresponds to 60-70% of the workers of the sector. This means that a great part of the workforce

[1] Annual invoice between US$ 480,000.00 and US$ 24,000,000.00 - 1 U.S. dollar (US$) = 2.5 reais (R$).

do not have access to the minimum required for working conditions. The participants responded that 48.8% already have the ISO9000 and 87.2% do not have any type of regulation for health and security in the workplace such as the SA8000[2] and the BS8800[3] certifications. Social norms, codes and certifications can surely help establish fair labor standards within the workplaces.

The sector demands from suppliers, according to the survey: legal, commercial and civil rights aspects. They do not identify concerns with the environment. The CSR related to the environment, according to

Table 2 – Main Driving Forces of the construction industry of the State of Bahia to adopt CSR

Issues		Objectives	Frequency
Internal	Workplace	**Employees motivation**	**61%**
		Attract and retain employees	**67.5%**
	Business	**Higher the clients/consumers´ satisfaction and fidelity**	**65%**
		Competitive advantage	**67.5%**
		Promote dynamism to the market	46.3%
		Access to capital and financial investments	29.3%
		Higher the CSR in the supply chain	22%
	Image	**To aggregate value to the image**	**58.5%**
		Have the recognition of the managers as business leaders	**61%**
External	Environment	**Preserve natural resources and provide environmental sustainability**	**56.1%**
	Society	Reduce social problems	48.8%
		Improve ethical and democratic standards in the society	48.8%
		Reduce poverty	48.8%
		Improve job generation	30%
		Promote the rights of the minorities	29.3%

Source: CSR survey applied by FIEB (2005)

[2] Social Accountability 8000 was developed in 1997, dedicated to improving workplaces and communities through voluntary standards combined with public reporting. It covers all core international labor rights: ILO Conventions, the International Declaration of Human Rights and the UN Convention on the Rights of the Child.

[3] British Standard 8800:2004 was written with the help of the Health and Safety Executive (HSE) to help organizations develop a framework for managing occupational health and safety, so employees and others, whose health and safety might be affected by the organization's activities, are adequately protected.

Table 3 – Main Practices of CSR in the construction industry of the State of Bahia

<table>
<tr><th>Stakeholder</th><th colspan="2">Practices</th></tr>
<tr><td>Employee</td><td colspan="2">Nourishment (basic food support and meals during working period)
Health (medical assistance and medicament refund)
Professional qualification (development of abilities and employment opportunities)
Education (basic and higher education)</td></tr>
<tr><td rowspan="2">Supplier</td><td>What is required by the construction firms</td><td>Attend legal, fiscal and social welfare policies
No use of unfair competitive behavior
No use of child labor
Participation in social programs of the construction companies</td></tr>
<tr><td>What is offered by the construction firms</td><td>Training
Support social programs of the suppliers</td></tr>
<tr><td>Consumer</td><td colspan="2">Product recall
Protection against fraudulent, deceitful, or grossly misleading information, advertising, labeling, or other practices.
Consumer service after sales
Clients´ satisfaction survey</td></tr>
<tr><td>Community</td><td colspan="2">Material giving
Money giving
Support government or NGOs social programs</td></tr>
<tr><td>Environment*</td><td colspan="2">Good operational practices
Internal recycling
Risk management
Environmental education and training for the employees
Reduction of the use of water and energy
Environmental License</td></tr>
</table>

Sources: CSR survey applied by the FIEB (2005), * Environmental Management survey applied by the FIEB (2004)

the results are more reduced to the legal requirements and economic issues. This gives the idea that most companies in this sector are still in the level of social obligations, described in the first level of the Leão-Aguiar *et al*. model. They assume the idea that society, government and NGOs, already make hard pressure for environment preservation. According to the participants, corporate philanthropy is not a common practice in the sector. The great difficulty is the crisis that affects the sector in the last years: the business community is more concerned with financial issues rather than on social issues. However, the ADEMI-BA, through partnerships with the businessmen, develops voluntary programs in the area of hospitals and nursery schools, with money and material giving.

CONCLUSIONS

This paper has attempted to understand what is meant by Corporate Social Responsibility in the construction industry of Bahia, how and why business might undertake such behavior, at the same time, proposing a new model to assess CSR practices. It is believed that adopting CSR practices represents a window of opportunities for this sector in a State that still have poor social records. According to the findings of the research, the main driving forces for the construction industry to adopt CSR practices are: a) to retain and motivate employees, b) to increase consumers' satisfaction and corporate image, c) to gain competitive advantage and recognition of good leadership, and d) to contribute with the environmental sustainability. It was also found that the main practices of CSR, generally, go from the fulfillment of current social norms and legal obligations and isolated practices of philanthropy, to an attempt to think strategically about social and environmental issues. There is no evidence at this stage of the research to suggest that the companies in the construction industry of Bahia adopt CSR as a Social Commitment (third level of the Leão-Aguiar *et al*. model).

This work understand that ethics in business are not merely philanthropy but an essential foundation upon which businesses are founded and through which business improvement can be achieved and better communities developed. CSR is found to have a strong "ethical anchor", although many firms in the construction industry of Bahia understand CSR as an instrumentalist perspective where corporate image and goals are of prime concern. It is important to find a balance between these sides of CSR without compromising the organization commitment with its stakeholders.

A sustainable construction strategy based on CSR, ethics and sustainable development will be derived through systematic efforts of the construction industry for the consolidation of a more steady, rational and harmonious society, based in principles of fairness and justice in the relations between the people inside and outside the organizations, also in a global level. The construction sector with its labor-intensive nature activities is able to play a major role in human development and improving the quality of life for the poor, that represents the major workforce of the construction industry. The sector can also contribute to promote a cleaner environment, adding the most value to products and services with the minimum use of resources and pollution. It will depend, ultimately, on the top managers to indicate to employees and society that they believe ethics and sustainable development should receive high priority in all business decisions, and a giant step is taken toward improving CSR performance.

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Strategic Management Practice and Tendency in Vietnamese Small-and-Medium Size Construction Firms

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Abstract
The application of business and strategic management in the construction sector in Vietnam appears to have been very limited. However, in the progress of economic transition from a centrally subsidised economy to a mixed market economy, managers in small and medium size enterprises (SME) in construction need to be prepared to change. This paper first reviews the application of models of strategic management in construction worldwide. It then builds a picture of the current situation of Vietnamese construction SME in terms of business and strategic management using a preliminary descriptive survey. Based on this, the paper predicts the trend that strategic management may be applied to this type of firm in Vietnam. It forms part of ongoing research that aims to build a strategic model for Vietnamese construction SME using grounded theory. The objective is to assist managers in changing their approach to business planning in the context of an emerging mixed market economy and provide guidelines in the effective application of strategic management to their organisations.

Keywords
Small and medium size construction firms; strategic management; Vietnam construction firms;

INTRODUCTION

After Vietnam declared "renovation" in 1986, its economy has been transformed from a centrally planned economy into a socialist-oriented market economy, which Sloman (1999) classifies as a "mixed economy". The country now is in a process of integrating into local and global markets through obtaining its membership of regional and international organizations. Vietnam joined the Association of Southeast Asian Nations (ASEAN) in 1995 and has been negotiating for the World Trade Organisation (WTO) membership. Together with the whole economy, the construction industry has begun its reform to adapt to this new environment. The construction industry plays a very important role in the Vietnamese economy. GDP from construction sector in Vietnam accounts for about 7-8% of GDP and maintains its 4th position. It provides jobs to approximately 1 million people in 2001, which accounts for about 2.4 %- 2.8% the whole labour of the country [GSO, 2005].

Forming an important part of the construction sector, Vietnamese SME in construction have begun to be integrated into the local and global markets. To survive and develop in a new, more competitive environment, the application of business and strategic management becomes vital to them. This paper discusses the business and strategic management practice and tendency in SME in construction.

THE VIETNAMESE CONSTRUCTION INDUSTRY AND CONSTRUCTION FIRMS

In Vietnam, construction firms, which operate as construction contractors, form the construction industry. They disperse under various ministries and provincial agencies, but the major management role belongs to the Ministry of Construction. Construction firms are registered firms that carry out activities in construction sector. In other words, they register one of their core businesses as construction of project. They can be classified as large, medium and small enterprises by size. SME are registered firms whose registered capital is less than 10 billions Vietnam Dong (nearly 633,000 USD); and/or the number of regular employees is under 300 [Decree 90/2001/ND-CP, 2001]. There is no clear criterion to differentiate small and medium size enterprises. Table 1 illustrated number of SME in recent years. However, the criterion on labour size is not important as the other criterion in construction, because construction firms tend to use a large quantity of seasonal workers in projects, which often cannot be finished in a short period of time.

Table 1. Number of SME in construction by labour size [General Statistics Office, 2005]

Year	By labour size					Total SME	Total enterprises
	<5	5-9	10-49	50-199	200-299		
2001	435	777	2522	1204	231	5169	5693
2002	449	1282	3683	1527	248	7189	7845
2003	514	1615	4768	1924	261	9802	9717

The Vietnamese construction firms, including SME, have limited competitive capability in comparison to overseas firms [Tran, 2001]. This fact was the result of the historical business environment. Under the bureaucracy mechanism, the work (construction projects) was allocated by the upper agencies, such as the Ministry of Construction and other ministries which controlled professional construction projects [Tran, 1999]. Through a period of economic reforms, this mechanism was ceased when the regulations on bidding was released. However, most of construction enterprises, especially SME, got the contracts through their "good relationship" with clients [Tran, 1999]. Tran (1999) argues that most SME in construction in Vietnam do not care enough about long-term planning. He points out two main reasons: (1) the managers of SME have not been well familiar with competition in a clear environment and (2) they do not have enough knowledge of business management, include strategic management. Therefore, in the changing environment when Vietnam opens the door for overseas contractors and the legislation system in construction have been adjusted, many Vietnamese contractors lose even "on their field". Large companies admit to act as subcontractors for foreign contractors, local SME fail in local projects. They are seen passive in the new environment. Tran (1999) comes to conclusion that construction companies in Vietnam, including SME, should apply business and strategic management into their organisation.

LITERATURE REVIEW ON STRATEGIC MANAGEMENT

Much research has been carried out into business and strategic management in developed countries, where the market economy is well established. Houben *et. al.* (1999) define strategic management as "a collection of decisions and actions taken by the business management in consultation with all levels within the company to determine the long-term activities of the company". Ansoff (1987) argues that there are 3 types of decisions in organizations: operating decisions with the lower management levels; administrative decisions, which are made in middle management level; and strategic decisions, made by top management of the firm, "relate[s] the firm to its business environment". Normally, the first type relates to short-term time horizon, whilst the second deals with both short-term and long-term and the third type is issued for long-term time prospect [Langford and Male (2001), David (1999)].

David (1999) divides the strategic management process into three stages: strategy formulation, strategy implementation and strategy evaluation. Mintzberg (1994) splits his strategy formation process into 3 phases: *creation*, *evaluation and choice* and *implementation* of strategy in his "Design School" model. Kew and Stredwick (2005) refer to strategic analysis, strategic choice and strategic implementation. Use the similar approach as Kew and Stredwick, but Langford and Male (2001) use the same terminology as David (1999) did for the first stage: "strategy formulation". In their work, the first stage of David's (1999) model is split out onto two stages: strategy formulation and strategic choice, whilst the 2 later stages are merged into "strategy implementation".

Langford and Male (2001) state that strategy formulation begins with defining the firm's mission. A clear mission is needed because it is very important to the performance of a firm [David, 1999]. Then, to help establish long-term objectives, five groups of key external factors should be assessed in the external audit: (1) economic forces; (2) social, cultural, demographic and environment forces; (3) political, governmental and legal forces; (4) technological forces; and (5) competitive forces [David, 1999]. The first four groups can be analyzed in a PEST analysis (Political/Legal, Economic, Social and Cultural and Technological Environment Analysis) [QuickMBA, 1999]. According to Porter's Five Forces Model, the fifth group in turn can be referred to as a framework of five forces: entry barriers, suppliers, customers, substitute products and industry rivalry [QuickMBA, 1999]. Two other tools often used in external audit include the External Factor Evaluation (EFE) Matrix and the Competitive Profile Matrix (CPM). The internal environment is assessed with the analysis of the firm's strengths and weaknesses by conducting an audit of internal core operations: management, marketing, finance/accounting, production, research and development, and computer information systems. The Internal Factor Evaluation (IFE) Matrix can be a useful tool for this task. A Strengths – Weaknesses – Opportunities–Threats (SWOT) analysis can be performed as a synthesis of internal and external analysis. "Competitor analysis" and "strategic group analysis" are two techniques that help understand the external environment [Langford and Male (2001), David (1999)].

According to Kew and Stredwick (2005), strategic choice involves a process of generation, evaluation and then selection strategic options. After Porter, Langford and Male (2001) discuss three generic alternatives of strategy: cost leadership, differentiation and focus and conclude that there exist only two major strategies in practice: cost and differentiation, which may require a change in direction. David (1999) suggests 13 alternative strategy directions that firms could consider – forward integration, backward integration, horizontal integration, market penetration, market development, product development, concentric diversification, conglomerate diversification, horizontal diversification, joint venture, retrenchment, divestiture, and liquidation – and a combination strategy. The following techniques and tools are suggested to use in this stage: SWOT, Strategic Position and Action Evaluation Matrix, Portfolio Analysis as Boston Consulting Group Matrix, etc. [David, 1999].

"How to put the selected strategies into practice" is the duty of the final stage of strategic management process, which Langford and Male (2001) call "strategic implementation and feedback". This stage relates to the establishment of annual objectives and the execution of management functions so that formulated strategies can be carried out [David, 1999]. Whilst Kew and Stredwick (2005) refer to it as "the most difficult phase of the whole process", Langford and Male (2001) state its problem as the matter of matching the existing organizational structure with selected long-term strategies. Therefore, some fundamental changes in the organization's structure are needed. Managing change becomes the key for this phase's success. There may be some resistances to change, in either form of resistance to the content of change or the process of change, occur within the firm. As a result, Kew and Stredwick (2005) conclude the importance of human resources as a "crucial role" in change management.
Three fundamental characteristics of construction product - fixedness, diversity and bulkiness lead to three significant features of construction service- mobility, uniqueness and majority outdoor activities [Nguyen, 2003]. Those features bring about two different types of market in construction [Langford and Male, 2001]. They are: (1) Contracting wherein price is determined before production; and (2) Speculative construction, which involves a traditional manufacturing approach, where built structures are often constructed before sale. Since the second type is newer in construction, Chinowsky and Meredith (2000) come to conclusion that project management topics receive more significant attention than strategic management. Not many researchers have been working on strategic management in construction. Langford and Male, Chinowsky and his coworkers are some of the pioneers.

As the work of Chinowsky and Meredith (2000), Langford and Male (2001) illustrates, strategic management in construction firms is generally similar to that in other firms. However, there are some distinctions in each stage of the process due to the distinct features of the industry. Seadon *et. al.* (2003) emphasize the core relation between strategic decisions and innovation in construction firms. According to Langford and Male (2001), in large construction firms there are some form of regional "subsidiary" structure acting as strategic business units together with the corporate level where corporate strategy is developed. The production level on construction site involves decisions on an operating or production strategy. They also point out some characteristics of construction firms that demonstrate good strategic management processes. Major characteristics include: (1) Formulating an overall strategy at the strategic apex; (2) Expecting operating units to develop and present their own plans to the main boards such that they can be consolidated into a single plan; (3) Using planning departments to provide contextual background information, undertake analysis and develop the board's thinking into operating plans; and (4) Having mechanisms in place that permit their strategies to be changed if the external and internal circumstances necessitate it.

Despite the fact that the construction industry comprises many more small and medium than large organizations, there is rarely research into the SME. In a developing country as Vietnam, when the construction industry is developing to integrate into the local and global markets, more attention should be paid to business and strategic management in SME in construction in order to help them operate firmly in a new and more competitive environment.

RESEARCH OBJECTIVES, METHODS AND PROPOSITIONS

The paper aims to support long-term research into the development of a strategic model for Vietnamese SME in construction. It explores the current strategic management issues in that type of firm and points out the tendency of the application of strategic management. The work has been done by conducting a "gap analysis" or comparison the practice in Vietnamese SME in construction with an existing model of strategic management. Due to the fact that no model for SME in construction has been found, the paper used a general model of strategic management process in construction firm that Langford and Male (2001) discuss in their work.

Based on the experience of one of the authors working in the industry in Vietnam, a general proposition has been raised: "Vietnamese SME in construction is at their embryonic stage of applying strategic management". For further validation, this general proposition is divided into 4 detailed propositions. They are: (1) Whilst Vietnamese SME in construction value annual and project plans, less attention is paid to long-term planning; (2) Plans in Vietnamese SME in construction are not strategically formulated; (3) Vietnamese SME in construction use some strategies instinctively; and (4) Vietnamese SME in construction are not concerned about change management.

DATA COLLECTION

Primary data for this research were collected from 30 internship reports that full-time and part-time fifth-year undergraduate students from the Construction Economics Faculty, Hanoi University of Civil Engineering, submitted in the last academic year. The reports present the organization's business management process and evaluation of each student on the firm's activities. The structure of the sample used is illustrated in table 2, 3.

Whenever the data in the sample is insufficient, other sources of information should be tried. Available sources that support the main data include tendering documents, website and the secondary data from previous research.

Table 2. Structure of the sample by region and sector

Total	Geographical region		Sector and type		
	Local	National	Joint-Stock Companies (SC)	State-Owned (SO)	Private sector (PR)
30	12	18	6	22	2

Table 3. Structure of the sample by governmental management bodies

Under ministries						Under provincial agencies				
MOC	MARD	MT	MOET	MOI	MD	Ha Noi	Hoa Binh	Da Nang	Quang Nam	Nam Dinh
8	3	1	1	1	4	6	2	2	1	1

(**Note:** MOC: Ministry of Construction; MARD: Ministry of Agriculture and Rural Development; MT: Ministry of Transportation; MOET: Ministry of Education and Training; MOI: Ministry of Industry; MD: Ministry of Defence)

RESEARCH RESULTS

Strategic Management Practice in Vietnamese Small-and-Medium Size Construction Firms

The proposed detailed propositions are examined to validate the general proposition.

> **Proposition 1:** Whilst Vietnamese SME in construction value annual and project plans, less attention is paid to long-term planning.

Table 4 shows that only 3.3% firms (1 firm) on the survey has clear and documented mission. This company is applying ISO 9000:2000 standard and the mission is established under the requirement of this application. No firm has a long-term plan. They only make plan over 1 year for individual project that they are carrying out. In majority of firms (2 PR and 18 SO), even annual plans are made by adding up the figures of project plans in the designated year. Proposition 1 therefore can be accepted.

Table 4. Mission and plans

	Local	National	SC	SO	PR	Total
Firms have clear, documented mission	0%	5.5%	14.2%	0%	0%	1 (3.3%)
Firms have annual plans	100%	100%	100%	100%	100%	30 (100%)
Firms have project plans	100%	100%	100%	100%	100%	30 (100%)
Firms have >1 year plans	0%	0%	0%	0%	0%	0%

> **Proposition 2:** Plans in Vietnamese SME in construction are not strategically formulated.

The survey shows that 28 firms, except for 2 PR, use the approach of 2 top-down, 1 bottom-up to make their annual plans. This approach should make use of the participation of every management level in the firm. In fact, in 24/30 firms, the lower management levels act as the plan receivers only. Only in 6/30 firms, which have remote regional units, those remote units take the real parts in planning processes. The two PR use the top-down approach, because their organizational structure is simpler and the management boards think they can cover all the firm's operations (based on an unofficial conversation with the directors of the firms). 100% firms make annual plans by listing the projects that are being executed, projects on tendering process that planners predict they can get. No firms analyzed systematically external and internal environments. No strategic tool such as EFE, IFE or SWOT, etc. has been used (in 100% firms). No forecast tools have been used. Plans at functional/operational levels are based on projects individually because no aggregate plan has been formed across all projects (in 100% firms). Proposition 2 therefore can be accepted.

> **Proposition 3:** Vietnamese SME in construction use some strategies instinctively.

100% firms on the survey have more than 3 core businesses. 100% SO (22/22) registered for new businesses under the guide of upper management agencies. 100% PR (2/2) registered for new businesses because the directors have good relationship with the owner/ owner representative in their local area. 6/6 SC have more than 3 core businesses as the inheritance of the original companies before privatization. It can be concluded that in 100% of the firms on the survey, the strategy of diversification has been used, but the decision was not made from a strategic choice, but external factors. However, 14/30 firms use backward integration strategy by registered a business of manufacturing some types of semi-product material after carrying out some preliminary research.

100% firms choose to act as sub-contractors in order to get more projects and let sub-contracting (e.g. roof, ceiling, doors and windows, etc… work) to strengthen their capability. As a result, it can be concluded that the firms on the survey take some strategies instinctively, but other under strategic choice. Proposition 3 therefore should be accepted partly and rejected partially.

Proposition 4: Vietnamese SME in construction are not concerned enough about change management.

Since there only one firm on the survey have clear and documented mission, it can be concluded that almost of the firms do not have a clear vision of the future direction. This characteristic is needed for a firm that is successful at change management [Langford and Male, 2001]. Only 16.7% (5/30) firms have plan on education and training for staff. Apparently, in other firms on the survey, there is no concern for the welfare of staff. Within the firms on the survey, the rate of staff with business administration or equivalent degree in overall is less than 2%. Majority of the firms (25/30) do not make any recruitment procedure. 100% firms make only labour-payment plan, which is a very low level of human resource management. Based on the conclusion of Langford and Male (2001), it can be stated that most of the firms on the survey are not successful at change management. Proposition 4 therefore could be accepted.

The results of the survey illustrated a picture on the current practice of strategic management in Vietnamese SME in construction. Apparently, some of the components of strategic management have been applied unintentionally or on purpose into SME in construction in Vietnam. But, the survey also points out that they are not used in a systematic way. However, in the market economy, strategic management perspective becomes the need of construction organizations [Chinowsky and Meredith, 2000]. The tendency in Vietnamese SME in construction will be discussed in the next paragraph.

Strategic Management Tendency in Vietnamese Small-and-Medium Size Construction Firms

When the Vietnamese economy transforms to integrate into local and global markets, SME in construction in Vietnam need to renovate to adapt to the new environment. State-owned construction firms are losing the subsidy from upper management agencies [Tran, 2001]. Many state-owned construction firms are being privatized and restructured [Nguyen, 2001]. They become stronger and form the new rivalry of SME. Many new SME in construction enter the market each year. Table 1 shows that the number of SME in construction (by labour size) increased over 75% from 2001 to 2003. The market therefore becomes more and more competitive. The threat from international competitors is also a significant factor when Vietnam has to open wide the market for them to enter after Vietnam joins WTO (expected by the end of this year – 2005). Tran (2001) concludes that the competitive ability of Vietnamese construction firms is very low. It is a significant weakness when they compete to regional and international competitors. Therefore, applying strategic management to help adapt to the new business environment becomes vital for construction firms [Chinowsky and Meredith, 2000], including Vietnamese SME in construction.

The results of the survey point out that Vietnamese SME in construction now are at a very low level of business and strategic management. However, in the emerging mixed market economy, favourable conditions have been developed for them to change their approach in business planning. First, the lessons come from overseas and international joint-venture companies that SME works with as sub-contractors will help them to develop the awareness on the field. Second, the movement of privatization in state-owned firms has affected to the trend of restructuring in other firms, which help them to approach easier to change management. Third, the significantly increase in number of staff that firms have been sent to re-train in the Construction Economics Faculty, Hanoi University of Civil Engineering (around 4 times in the last 7 years [FCE, 2003]), in the number of part-time students who are working in firms (5 times from 1995 to 2003 [FCE, 2003]) illustrates the fact that they are now concerned more with the welfare of staff. The higher rate of staff holding bachelor or higher degrees in the firms (about 5% - data from the survey) would seem to be an advantage. Fourth, the issuance of new and stricter legislation has helped to develop a more clear and fair construction market. As a result, construction firms, including SME, have to find alternative strategies to get projects instead of obtaining by “good relationship”. Lastly, the Vietnamese Government has made many efforts to aid SME, including SME in construction. The Decree 90/2001/ND-CP was issued in 2001 to create a new environment for SME to develop. A SME support Centre in charge of SME was founded in the Vietnam Chamber of Commerce and Industry. This Centre is organizing courses to train SME on business and management knowledge. In addition, the Mekong Private Sector Development Facility funded by 12 donors, including the Asian Development Bank has been offered a variety of services to SME to support and accelerate their development. In short, better conditions have been created for SME in construction in Vietnam to apply business and strategic management to develop.

CONCLUSION

SME in Vietnam are enterprises with registered capital under 633,000 USD; and/or the number of regular employees less than 300. In the Vietnamese construction industry, SME account for more than 90% total enterprises, employ approximately 40% employees and produce about 47% the total net revenue for the industry (General Statistics Office, 2005). Therefore, they form an important part of the industry. In the new business context when Vietnam integrates into local and global markets, that type of firm will face many challenges. This paper first reviews the theories and practice of strategic management issues in firms in general, then particularly focuses on that of construction firms. A survey has been conducted amongst 30 SME in construction in Vietnam to study on their business and strategic management practice. The result shows that in those firms, business and strategic management has not been applied systematically. Firms do not have properly “vision” of the future. They focus only on project plans and annual plans, which have not been formulated strategically, not on long-term plans. They use some strategies, but in an instinctive way. They do not aware enough about change management in construction industry. Therefore, it can be concluded that Vietnamese SME in construction is at their embryonic stage of applying strategic management. Nevertheless, those firms tend to develop their application of business and strategic management in the context of an emerging mixed market economy. Both internal and external factors now create favourable conditions for the trend. As a result, those firms are paying more attention to business and strategic management.

However, literature shows that no particular model of business and strategic management for SME in construction has been found. Long-term research in which this paper forms a part is being conducted into that issue, aiming to assist managers in Vietnamese SME in construction to change their approach to business and strategic management in the context of a new emerging mixed market economy.

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An Assessment of E-Business Implementation in the US Construction Industry

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Abstract
The construction industry is one of the most people-intensive industries in the world. Construction also is known for its conservative attitude toward adopting technology in the last decade. Traditionally, the construction industry is the last one to accept changes brought by advancements in technology when compared to other industries. Today, as e-Business has shown it is beyond a new cool hype, the construction industry has started to respond to it, by reforming the way it does business.

Has the US construction industry redefined its way of doing business based on e-Business? This study explores the answer to this question by determining current e-Business implementation solutions in the construction industry and discussing the future implementation potential for various industry participants–general contractors, design firms, material re-sellers, and sub-contractors in general. It focuses on the adoption of e-Business into project management systems by general contractors. The development of business transactions such as e-Procurement, trade exchange, and business strategies such as customer relationship management (CRM), project collaboration, project management, enterprise resource planning (ERP), and knowledge/data management are discussed. This study compares the results of a previous survey completed by the authors in 2000 with a similar survey done in 2005 and concludes that the US construction industry is still a long way from being saturated with e-business applications.

Keywords
e-Business, e-Marketplace, e-Procurement, globalization, internet

INTRODUCTION

Construction is the second largest industry in the U.S at $3.4 trillion annually. E-Business initiatives have transformed industries and the WWW has become a source for information, goods, and services, and a means of communication. This study reports on a survey conducted to assess the construction industry's attitudes and perceptions with respect to e-Business. The questions were designed to find out how far the construction industry respondents have advanced in the implementation of e-Business applications, what type of companies use e-Business transactions, and to what extent they use these applications. The survey is focused on the company size, geographical distribution, revenue, e-Business transaction use, and e-Business investments and future plans for e-Business implementation. This study is based on a combination of mail and web-based responses from 21 corporations out of 91 organizations selected from the 2004 Engineering News Record Top 400 Construction Companies. The businesses surveyed represent project management and construction services companies throughout the U.S. and varied in terms of annual revenues, workforce size and geographical locations.

A summary of the savings and efficiencies that are derived from the application of e-business in construction is shown in Figure 1. New business trends force the industry to deliver a better product with enhanced customer involvement and satisfaction. To achieve this critical goal, businesses have to expand their market to the world, so that every player in the industry becomes highly developed in their niche market. Producing the best quality product and achieving the highest level of customer satisfaction requires all the team players to work jointly on their project through Internet tools. This will improve the quality of the end product satisfying the client, and will also improve the efficiency of product development satisfying the project team. The construction industry derives improved efficiencies out of e-Business besides just cost cutting.

Figure 2 shows the relationships between various e-Business initiatives in the construction industry. E-Business enables transactions to take place online, thus increasing the accuracy and efficiency of business transaction processing while optimizing business processes, condensing business cycle times, reducing cost, and improving customer service. It eliminates obstacles between corporate and business partners or customers. It enables partners and customers to communicate and share information via the Internet, and it is used to serve customers, and provide the right information to the right people at the appropriate time. Market transparency for its customer-corporations, suppliers, customers, partners and marketplaces is created by e-Commerce.

Figure 1. Effects of e-Business on the construction industry (BuildOnline 2000)

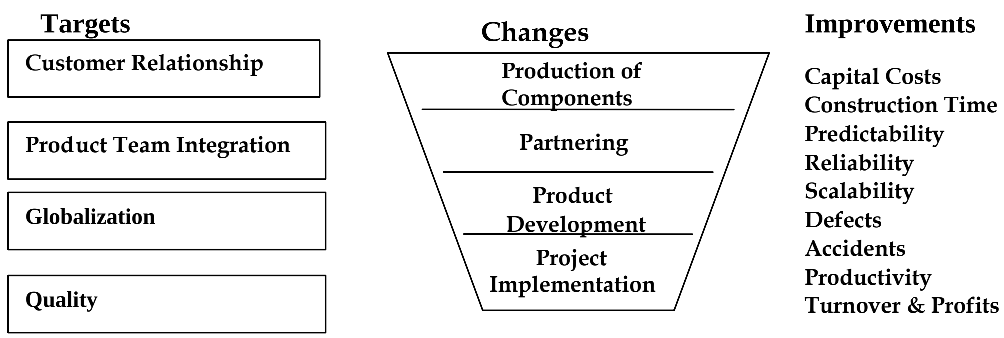
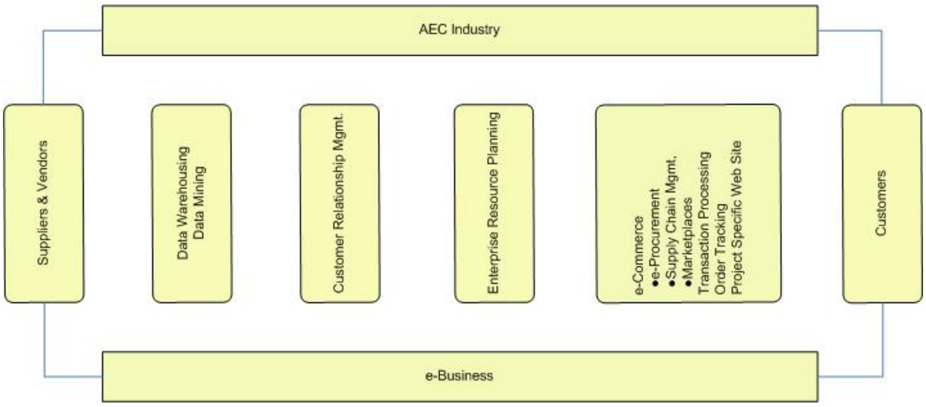


Figure 2. e-Business system diagram for AEC



Global construction projects come in different partnership formats such as joint ventures, outsourcing, and subcontracting or local representatives at the project location. This brings a new level of complexity to the industry: communication; different relationships; partnering; new markets; and global business standards and rules (Tucker 1997). For example, Bechtel, which is one of the largest construction companies in the U.S. (Engineering News Record Top 400 2004), exhibits a well-defined global structure. It has 41,000 employees working in 66 different countries. Bechtel booked $14.5 billion in new business for 2000 and had $14.3 billion in revenue (Bechtel 2001)

US CONSTRUCTION INDUSTRY

The Internet has the potential to rid the industry of inefficiency and cost. Because it has stuck to the old methods of regular mail, couriers, and faxes the construction industry often has a bad reputation for finishing projects late and over budget. However, construction industry leaders are leery of e-commerce because of the mere nature of the construction industry. It is an extremely people oriented business. Relationships are established with suppliers and subcontractors that last for years making the option of using a subcontractor found online, that one has never met before, a turnoff for most traditionally thinking leaders. However, e-Business still encompasses the people oriented nature of construction because of its own need for people. Without the human interface, the systems would not succeed at all. E-Business requires an integrated alignment of technology, operation, strategy, structure, and human interaction in a continuously expanding network (Chang and Ping Li 2003).

The benefits of e-Business are being realized by several businesses in various disciplines. Impacts realized by e-Business are not limited to reduced costs. Improved predictability, productivity, reliability, and scalability, ability to detect defects, improved levels of service, and extended market research are all advantages that are attracting more companies as well as software applications that allow users to get more for their money (Issa and Flood 2003). For example, Swinerton & Walberg Builders cut change order turn around time by more than half by using Bidcom.com, an online project management program (Fisher 2000). Because the construction industry is a multibillion dollar industry, the idea of saving time and money on daily operations should be a real concern. The construction industry claims that 60 to 80% of the total cost of operation, including capital, labor, materials and transportation, is directly related to information management (Greissler 2001). This information management pertains to everything from scheduling to ordering materials to designing and coordinating construction and shop drawings. More time is actually spent on the business side of construction with sharing information than is spent onsite actually constructing the structure.

The construction industry needs to be made aware of the advantages Business to Business (B2B) e-Business can offer in terms of speed and cost savings. The construction process is much more complicated than most other industries because of the variety of projects and the fact that every project is unique from owner to designer to project manager. This fact can make most standardized practices for other industries a nightmare for the construction industry. Because there are so many people involved in any construction process it can be difficult to process business transactions. Although project web sites are extremely useful in regard to team collaboration and exchange of documents and information, they really do not have anything to do with B2B e-commerce and the selling and/or buying of construction items and materials for a certain project. It is merely the sharing of information for projects and nothing more. "Without components, we are forced to revert to the traditional, manual, methods for identifying and quantifying the materials we need to purchase and erect. We inject a human right into the middle of our ecommerce transactions" (Cleveland 2001). Dealing with components are what makes processes easier thus streamlining activities and speeding up processes.

ANALYSIS OF E-BUSINESS ASSESSMENT SURVEY FINDINGS

In order to determine the degree of implementation of e-Business in the U.S. construction industry, an e-Business assessment survey was created. The survey was distributed to a random sample of 91 companies out of the 2004 Engineering News Record Top 400 US Contractors ranked by gross annual revenue. In addition to the demographic information about the 20 respondents, selected results of the survey are presented within the following four study areas: adoption of e-Business, communication tools usage, e-Business initiatives, and their prioritized goals for e-Business. The demographics looked at by the survey include the job function of the respondents, the size of their workforce, and the geographical distribution of their operations. Figure 3 shows the distribution of respondents by job functions. The large number of operation managers (30%) and executives (30%) responding to the survey indicates that these groups are the most involved in their construction company's e-Business decisions. The difference in workforce size distribution among the survey respondents is shown in Figure 4.

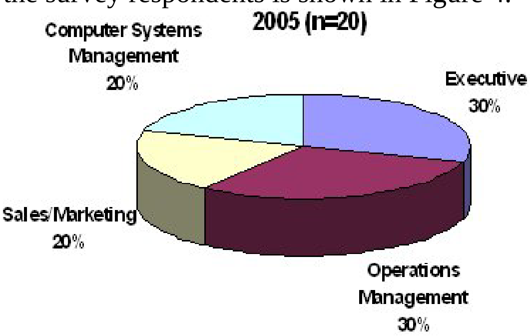


Figure 3: Job functions.

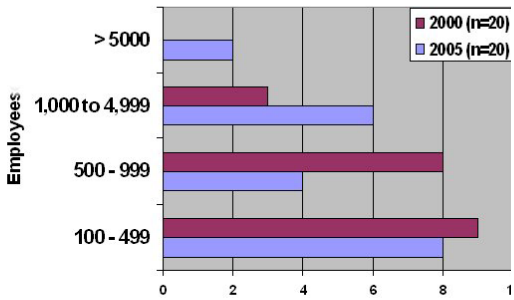
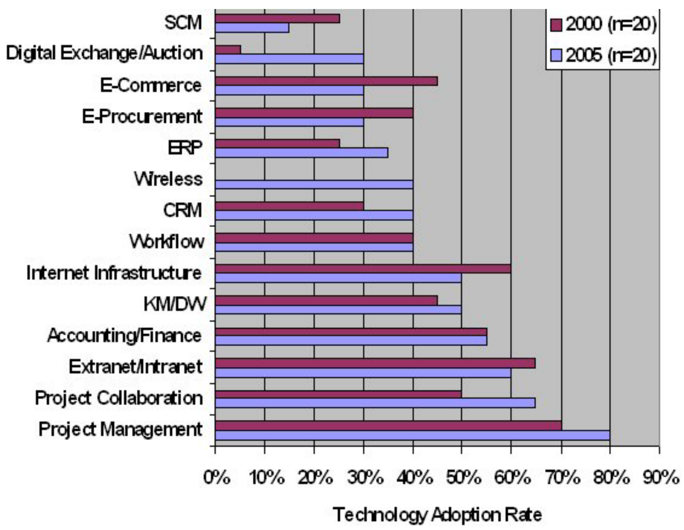


Figure 4: Workforce size distribution.

e-Business implementation

The distribution of e-Business applications implemented by the respondent companies is shown in Figure 5. Every company surveyed is involved with e-Business applications, in one form or another, within their company. The most widely used e-business application in 2005 is project management at

Figure 5: Distribution of Adopted e-Business Applications



80% (16) and project collaboration is close behind with a 65% (13) adoption rate. The survey results also show more adoption in the wireless category than in 2000. The survey in 2000 showed 0% adoption of any kind of wireless technology. In 2005 45% (9) of companies are utilizing the wireless technologies in part because of technological advances as well as greater user familiarity with this technology. Accounting and finance tools are among the most implemented tools and are used a great deal at 55% (11) with most internally developed. Although more than 45% of companies require cell phones, which use wireless technologies, respondents were most likely considering wireless connections for laptops on site and for data exchange over the Internet. The combination of these three tools has increased the adoption of each tool by itself and explains their greater adoption in the construction industry. Among the least adopted applications even though they have great potential in saving money and streamlining operations are e-Commerce (20%), e-Procurement (30%), digital exchange/auction (30%) and supply chain management (15%). The number of adoptions of these applications is sure to rise especially with the new generation of more computer savvy individuals getting ready to enter the construction work force.

Figure 6 shows the distribution of the respondents' types of connection with their customers and suppliers. Although the survey indicated that the construction industry most often uses the old method of communicating by phone or in person there is an increase in the use of e-mail by respondents. The use of wireless technologies has increased from 5% (1) in 2000 to 30% (6) in 2005. The use of public and private market places is still pretty low considering the increased use of digital marketplaces by other industries. The U.S. construction industry is heavily dependent on personal relationships and seems to still work by word of mouth, asking around and using past suppliers and manufacturers for business operations. If the need arises, wireless computing will allow the almost instantaneous reorder of any item from a digital marketplace from anywhere on a jobsite.

Figure 7 shows the distribution of the type of wireless computing devices supplied to employees. With the apparent use of these mobile computing devices it is clear that the construction industry is embracing these new technologies and looking for new ways to increase productivity. These devices simplify processes and streamline workflow which is exactly what the complex construction industry needs to increase its efficiency and its profits.

The distribution of e-Business initiatives among the respondents' companies is shown in Figure 8. Current practices and future implementation in procurement, supply chain, transactions, e-commerce, project development, intranet/extranet, e-markets, order tracking, partnering, and communication were all covered to determine the industry's needs. Ninety percent (90%) of the respondents have implemented e-Business initiatives and have plans for future e-Business initiatives within their

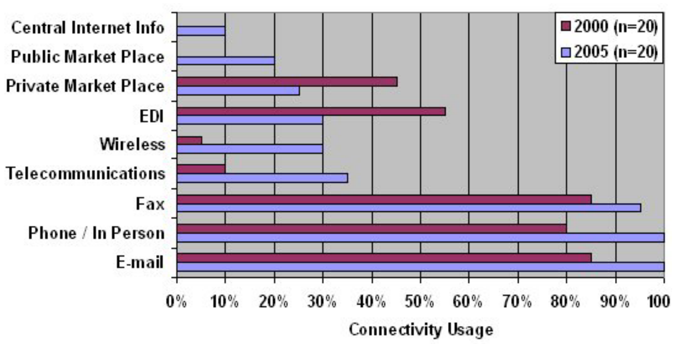


Figure 6: Supplier, Partner, and Customer Connectivity

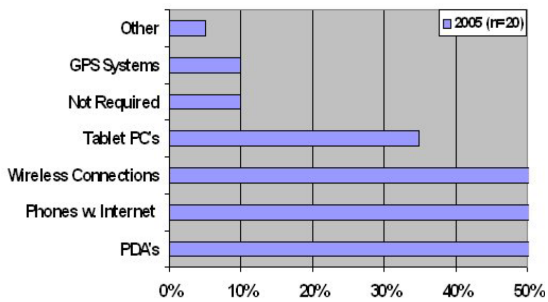
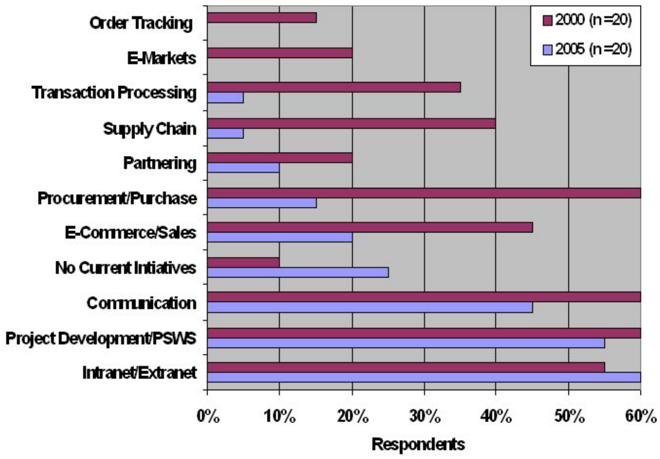


Figure 7: Supplied Computing Devices

organization. Project Development and Intranet/Extranet tools were the most used and/or are slated for greater use. The greater use of Intranet/Extranet at 60% (12) versus 55% (11) in 2000 was no surprise considering the high response rate earlier with regards to e-business applications. Communication was the next most frequently picked response among the initiatives with a 10% decrease from 60% (12) in 2000 to 45% (9) in 2005. With a constant need to keep in touch with suppliers, clients, and everyone involved in the project, communication is extremely important to construction industry leaders and most of the companies have probably already taken care of most of their basic communication needs since the previous survey in 2000. These tools are important for construction companies in order to maintain and increase productivity while reducing costs and staying on schedule.

Figure 8: Electronic Business Initiatives in the Construction Industry



Prioritized Goals of the Construction Industry

A comparison of the distribution of the respondents' company goals between 2000 and 2005 is shown in Figure 9. Increased productivity/profitability has become the most important concern for leading construction companies ranking fourth in 2000 and moving to the number one goal in 2005. Increased internal communication and enhanced customer relationship moved from first and second respectively in 2000 to tying for second in 2005. It is not clear as to whether or not the respondents or the construction industry are familiar with B2B exchange because 35% (7) of the respondents did not know whether their company had participated in B2B exchange in the preceding 5 years, while 40% (8) indicated no participation, and another 20% (5) indicated participation in this application. These results show that B2B exchange has not been implemented as much as expected, which may be due in part to the process itself, which involves entering information into a system and allowing the system to take it through the process with minimal human interface (Cleveland 2001). These problems are mainly due to the complexity and fragmentation of the construction industry.

Figure 10 shows the obstacles the respondents see the construction industry is faced with when conducting e-Business.   Since e-Business is relatively new to the construction industry there are few cases available of companies who have implemented e-Business applications with long term documented results. The respondents equally blamed a lack of expertise as the reason for the construction industry to be wary of implementing too much e-business at one time. E-Business is still relatively new to construction, which indicates that it is to be expected that there will be to be a lack of expertise in this area across the board.   However, with the increase in computer literacy among the construction workforce, the implementation of e-Business is expected to grow at a faster pace in the future.

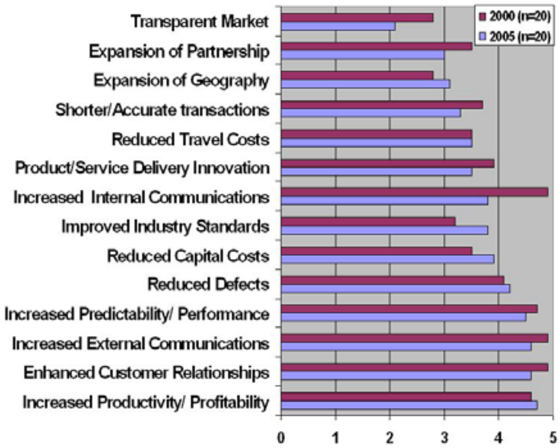


Figure 9: Prioritized Goals

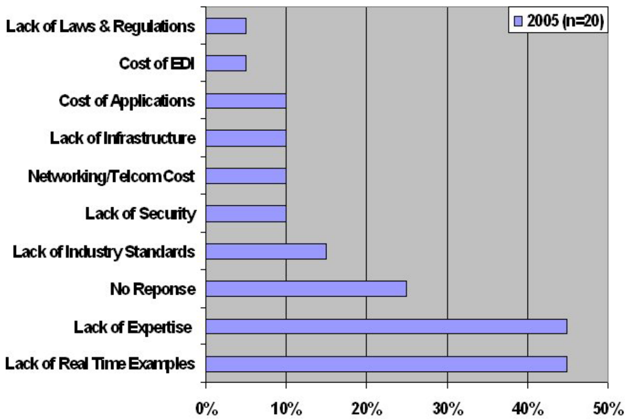


Figure 10: Reasons for Not Implementing e-Business

The results of benefits that the respondents have experienced with the implementation of e-Business applications are shown in Figure 11. The ability to retrieve project information with ease and to allow for more effective use of time are the greatest benefits noted by the respondents, with 35% (7) feeling these were the benefits their company was realizing. These benefits really go hand in hand, because with the better use of time comes cost savings which is another benefit the respondents perceived. Figure 12 shows the 2005 respondents perception of the impact of e-Business on revenue. Most of the respondents (35%) felt that their e-Business adoption had an impact on revenue. The four that did not respond were also the same individuals that felt they were not knowledgeable in their company's e-Business efforts.

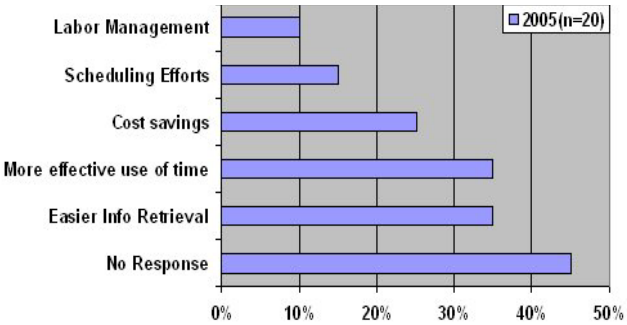


Figure 11: Improvements realized by construction industry

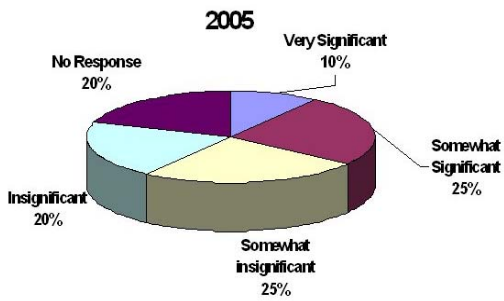


Figure 12: Impact on Revenue

Figure13 shows that an overwhelming number of the respondents have implemented e-Business in the hope of increasing productivity, thus leading to more effective use of time, and in turn cost savings. The construction industry is based on getting things completed as fast as possible with the least amount of steps. It is evident in this response that this "getting done" attitude is what is driving the decisions on e-Business adoption.

The respondents, as shown in Figure 14, show no signs of wanting to rid their operations of e-Business implementation. Either way they plan on continued spending on e-Business in the construction industry. The respondents seem to realize that e-Business implementation is benefiting business operations and that continued support for it is crucial to business success.

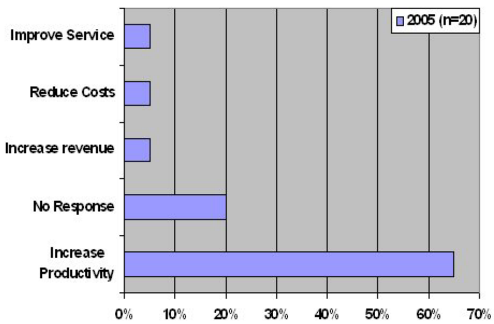


Figure 13: Perceived benefits of e-Business implementation

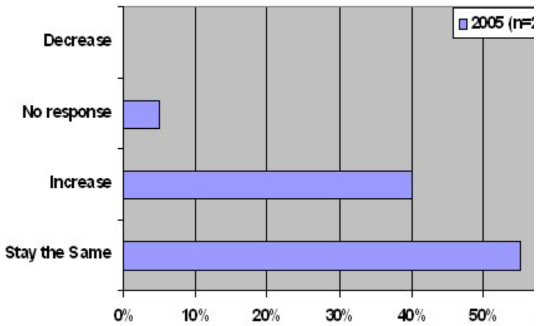


Figure 14: Expected Future Spending on e-Business Implementation

CONCLUSIONS

Companies that have begun to re-evaluate their technology needs and usage, that have evaluated new Web-based solutions, and that have developed, refined, selected and prioritized a set of solutions will be in a good position to realize considerable cost savings, to increase operating efficiencies and to improve customer satisfaction and profitability. E-Business is about the commitment and capability of companies in various industries to utilize digital technology and to enhance customer satisfaction across their business functions, thus changing their way of doing business from a traditional company-centric stand-alone paradigm to a new network-leveraged synchronized paradigm (Chang and Ping Li 2003). E-Business is the future and it is here now and companies must embrace these new technologies if they want to survive in this fast paced, dog eat dog world. The results of the survey indicate that although there has been an increase in the use of e-business from 2000-2005, the US construction industry is still a long way from being saturated with e-business applications.

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Internationalisation of housing developers from developing countries: a new research agenda

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Abstract
The objective of this paper is to draw attention of scholars to the emergence of housing developers from developing countries that have gone 'international'. The changing housing reforms, demographics and liberalisation of markets has enabled housing developers from certain countries to engage in housing development activities in some selected countries in Asia and Africa. Their achievements to date are contrasted with their counterparts from developed economies. The data used to support the argument is based on desk research. preliminary findings indicate that their experiences and markets are limited to certain types of developments and to certain countries. Also based on the experiences of their counterparts from developed countries, it can be anticipated that at the optimum level, they will operate within a narrow confines of housing development and in a selected overseas markets.

Keywords
Developing countries, housing developers, internationalisation

INTRODUCTION

A trend has been detected among developing countries of housing developers 'going international' following the footsteps of their construction contracting cousins. The objective of the paper is to draw attention to the need for scholars to give due attention to this emerging trend that will intensify in the coming years. Other studies (e.g. Sirmans and Worzala 2003; Stephens 2003) dealt with the issues of international housing deal from the perspectives of international real estate as means of investments by global financial firms. The first section of this paper will deal with the experiences of developers from developing countries that have been able to internationalise their activities. The next section then discusses the experiences of housing developers from the US and UK that can act as benchmarks to their counterparts from developing countries in terms of their internationalisation experiences. This paper is based on a preliminary work that looks into internationalisation of housing developers, with particular reference to Malaysian housing developers.

LARGE MARKETS IN THE ASIA

Various factors like availability of financing, excess capacity in home markets, increasing incomes in many developing countries along with housing reforms in many countries of the Asia Pacific region have made international housing developers to seek opportunities in these growing markets. These changes are reflected in the changing housing markets of China, India and Vietnam which together account for 40 percent of the world's population. China and Vietnam have moved from centrally planned economies to partly managed while India has undertaken extensive reforms in its economy enabling the reforms of the financial sector and reducing the "licence Raj" that held back the Indian economy. In China the reforms in the housing sector has enabled the private developers to take a leading role in expanding the housing sector. Recent data shows that private sector is responsible for about 70 percent of the housing development in China and in cities like Shanghai there is a negligible participation by state owned firms (Moody's 2004). India, rising incomes from liberalisation of the economy, repealing of restrictive urban limitations and the availability of housing finances at low interest rates have enabled the middle class to avail of housing loans from banks. The interest rates in India have come down from high's of 18 percent in the early 1990's to as low as 6-8%, thus enabling many of the professionals to avail of housing loans.

INTERNATIONAL HOUSING DEVELOPERS FROM THE ASIA PACIFIC REGION

In the Asia Pacific region there are four countries whose developers have expanded into undertaking international housing developments; Malaysia, Indonesia, Singapore and Hong Kong. Developers from each of these countries have expanded into international development for various reasons. For Malaysian developers, the need to have an export economy, which has been encouraged by the previous government and rising economic status of Malaysia, encouraged Malaysian developers to engage in internationalisation. For Indonesian developers, their case is motivated by the necessity to offset risks in the local housing market by channelling their funds to locations that will have minimum impact on expropriations. For Singaporean and Hong Kong based developers, the limited size of land holdings in the city states makes them proactive in looking for locations where their expertise and growing markets match. Housing developers from Hong Kong have been engaged in the Chinese housing sector since the middle 1980's and have subsequently increased their operations in China, since the return of Hong Kong to China in 1997. Fig. 1 indicates the exposure of Hong Kong based housing developers in China.

Hong Kong and Singapore based developers by virtue of their geographical proximity to China have had an advantage in the Chinese housing development sector (Moody 2004). The housing market in China has increased many folds after the housing market was privatized and allowed the commoditisation for foreigners and then gradually to locals (Liang & Ma 2004). The market for housing in China has also been aided by increasing rates of urbanization, rising middle class and upgrading of housing units (Liang & Ma (2004). The residential housing market is estimated to be growing at an average of 20 percent annually, with an estimated investment of renmit 1000 billion in 2003 (Moody 2004). The availability of mortgage for housing market also increased the potential number of buyers. Despite the growth of the housing markets in china, there has been disquiet from the state authorities on the effects that such annual increases of the magnitude of 20 percent will have on the Chinese economy. Curbs to the growth of the housing markets, to dissuade the speculators has been introduced. Among these curbs include the decrease the loan percentage that could be loaned out and have limited the sale of properties until completion of the unit. These policies have made capital scarce for local developers, which in turn have made them amenable to having foreign partnership in order to have access to capital.

Malaysian housing developers have had different experiences than those from Hong Kong, Singapore or Indonesia. The motivating factors that have increased the participation of Malaysian housing developers internationally are two fold. Firstly the promotions by the previous government of Dr. Mahathir of Malaysian business interests in other developing countries and having an export led economy where all sectors of the economy could contribute to the economic empowerment of Malaysia. Secondly since there has been a downturn in the Malaysian economy caused by the Asian financial crisis there has been a slowdown in the Malaysian construction, Malaysian contractors have since then moved into international construction and have subsequently diversified into housing development where such opportunities. In South Africa, Malaysian developers exhibit examples of the first motives, while Malaysian developers in India are motivated by the factor. Housing developers from the Malaysia, Indonesia, Singapore and Hong Kong have gained from their experiences in their respective countries, which had witnessed a tremendous growth and benefited from planned large scale developments. Malaysia and Singapore have reached a home ownership level of 85 percent and as such the penetration of the housing market has been extensive, leaving future growth margins, difficult to compare with earlier growth. In reflection of the experiences of Malaysian housing developers and their growth can be mirrored to the fact that 85 Malaysian property developers are listed in the Kuala Lumpur stock exchange, in contrast none of the Indian property developers is listed in the Bombay stock exchange, indicative of limited capabilities and restrictive growth opportunities

Indonesian developers have been active in Vietnam and India undertaking relatively housing developments compared to Malaysian housing developers. In Vietnam, Indonesian developer, Ciputra are currently undertaking housing development of an integrated city in the capital Hanoi. This is a US $ 1 billion project that took nine years for negotiations. In India an Indonesian consortium with local authority partnership is undertaking a US $ 350 million integrated township in the eastern city of Calcutta (Kolkata). Table 1 indicates the various housing developers from Asia and their partners in undertaking housing development. Most of the partnerships indicated in the table are with local authorities (municipalities, housing boards), which is indicative of the opportunities not having a complete market equilibrium.

Figure 1. China exposure of some Hong Kong based developers, Source Moody's (2004)

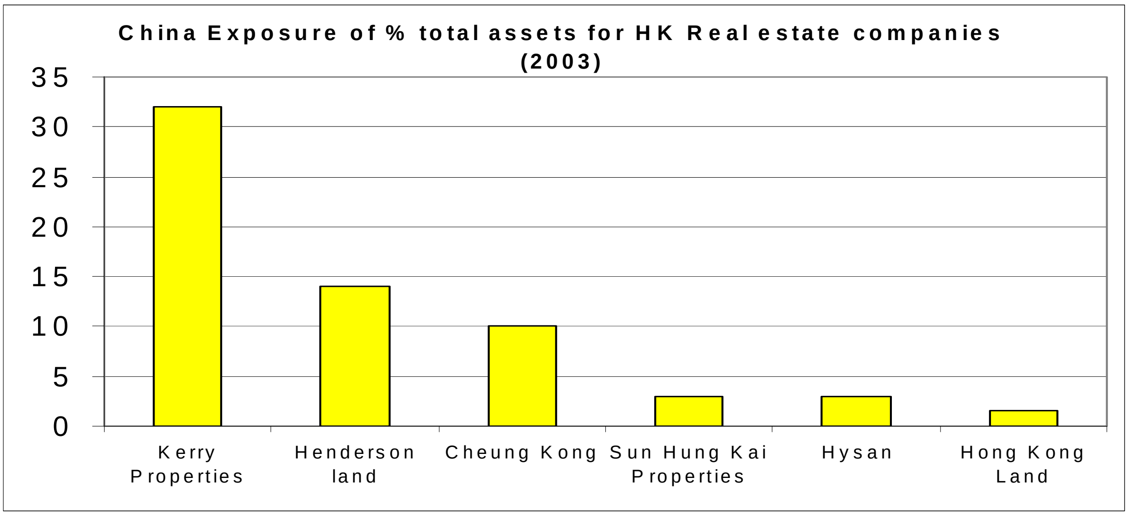

Table 1. Housing Development in Asia by Foreign Developers

Housing developer	**Location**	**Partner**
Shu On (Hong Kong)	Chongqing (China)	Chongqing Municipal Government (LA)
Ciputra (Indonesia)	Hanoi (Vietnam)	Hanoi Investment and Infrastructure Development Company (LA)
Ciputra Salim Consortium (Indonesia)	Kolkata (India)	Kolkata Municipal Development Authority (LA)
IJM (Malaysia)	Hyderabad (India)	Andhra Pradesh State Housing Board (LA)
Keppel Land (Singapore)	Ho Chi Minh City (Vietnam)	Chiap Hua Group
Keppel Land (Singapore)	Jakarta (Indonesia)	Modernland Realty
Central Trading & Development Corporation (Taiwan)	Ho Chi Minh City (Vietnam)	Tan Thuan Industrial Promotion Company (LA)
Ho Hup (Malaysia)	Hyderabad (India)	100%
Sunway group (Malaysia)	Phnom Penh (Cambodia)	Canadia Development Co.
Mitrajaya Development (Malaysia)	Johannesburg/Pretoria	100%

HOW BIG CAN HOUSING DEVELOPERS FROM DEVELOPING COUNTRIES BECOME?

Hint of the answer to this question can be found from developers from the developed countries of US and UK. Housing builders from the UK with international operations are John Laing, George

Wimpey, Taylor Woodrow, Barratt Development and Emerson International, whist house builders from the US with international arm are Centex, Pulte Homes, KB Home and Hovnanian Enterprise. The age of the companies ranged from 24 (i.e. Emmerson International) to 158 years (John Laing). Two are still in private hands (John Laing and d Emmerson International) while the rest publicly listed. They are large house-builders in their own country, dominating the top ten list in their respective countries for most years. All belong to diversified groups. George Wimpey diversified from construction to house building whereas Taylor Woodrow started as house builder and diversified into construction contracting. Mergers and acquisition seems to be the common tactic to grow large (see Table 2).

As can be seen from Table 2 and 3, theses companies operate within a narrow of selected countries. The host countries are either across the national border (e.g. USA and Canada, USA and Mexico), within nearby regions (e.g. North America and Europe, North America and South America), share cultural and linguistic similarities (e.g. UK and Australia, UK and North America). Overall it can be said that UK house-builders tend to favour North America and Australia whereas US tend to spread their international operations to South America. There is also a pattern of UK and USA house-builders penetrating contiguous countries simultaneously (e.g. Taylor Woodrow going into Spain and Gibraltar, Pulte Homes going into Argentina and Chile). Ambitions to operate over a wider territory may exist, but the hurdles can be insurmountable. Take the case of Centex which, in 1999, aimed to extend its reach throughout Europe over the next 5-7 years following its acquisition of Fairclough Homes. The plan was to create a pan-European house building company. Up until now however, Centex is still largely operating only in the UK.

Table 2. Summary of international venture of UK-based housing developers

Firm	**Year founded**	**Corporate status**	**Target country**	**Time of venture**	**Time of exit**
John Laing	1848	Private	US	1984	2001 (partial)
George Wimpey	1880 (venture into housing in 1920s)	Public	US	1984	
			Australia	(around 1980s / before US)	1999
			Canada	1950s	-
Taylor Woodrow	1921	Public	US	1935	-
			Canada	1963	-
			Spain	1960s	-
			Gibraltar	(Not sure)	-
			Australia	Present in 1994	2001
Barratt Development	1958	Public	US	1980	2004
Emerson International	1982 (Emerson Group formed in 1959)	Private	US	Early 1980s	-
			Portugal	1980s (shortly after US	-

Table 3. Summary of international venture of US-based housing developers

Firm	**Year founded**	**Corporate status**	**Targeting country**	**Time of venture**	**Time of exit**
Centex	1950 (Centex Homes International formed in 1998)	Public	UK	1999	-
			Mexico	Entering in 1993	-
Pulte Homes	1950	Public	Mexico	1994	-
			Puerto Rico	1973	-
			Argentina	2000	2005
			Chile	Present in 1998	-
KB Home	1957	Public	France	1968	-
			Mexico	Entering in 1993	-
			Canada	1970s	1995-1996 (wind down)
Hovnanian Enterprise	1959	From private to public (since 1983)	Poland	1996	2003

The motive for internationalisation can be explained by the 'push' and 'pull' factors. The 'push' factors are:

1. Need to continually grow. During the 1970s, Barratt Development was an obscure house-builder in the north-east of Britain. Since the early 1980s, the firm gained 11% of the UK market share. Following that, the company engaged in cross-border development to sustained continued growth of the firm.
2. Market diversification. Pulte Homes targeted non-US markets that offer the potential for rapid growth and substantial risk-adjusted returns. Markets like China, Russia and Hungary offer tremendous potential on paper, but the risks are equally significant. In the end the company the South American market was deemed to match the competitive strengths of the firm.
3. Low cycle in home market. Overseas turnover ensures steady future revenue. Centex experienced low slow cycles in the US housing markets. Initially planned to go into markets that just came out from down cycles such as France and Germany, but finally settled for the UK.

The 'pull' factors are:

1. Potential of target country. Booming economy and young population attracted Centex to Mexico, large Mexican migrants in the USA intending to return home attracted Pulte Homes to work in Mexico.
2. Growing economy. Hovnanian Enterprise chose the emerging economies of Eastern Europe, notably Poland, for its import-intensive economy.
3. Advanced real estate and mortgage laws. Compared to other Eastern European countries, Poland has the more advanced real estate and mortgage laws.

Mergers and acquisitions seem to be a common method of penetrating foreign markets (see Table 4). The acquired companies tend to be strong in their own right in their domestic markets. Hence the international operations of the surveyed companies may not be through direct operation but stake-holding in local companies.

Table 4. Mergers and acquisition trail of surveyed companies

Company	Merger and acquisition
John Laing (UK)	Merge with Watt Homes, one of the premier house-builder in western USA to form WL Homes LLC in April 1998. WL Homes become one of the largest privately held homebuilders in the US, especially in Southern California and Colorado.
George Wimpey (UK)	Acquired Morrison Homes in 1984. Morrison Homes ranked as one of the top 25 homebuilders in the US.
Taylor Woodrow (UK)	Acquired Journey Homes in Arizona, US in August 2002. Acquired Monarch Development Corp, one of the Canada's largest home builders (45% in 22 May 2000 & success integrated in 2004). Increased its shareholding in North Whitfords Estates Pty. Limited to from 50% to 100% in Australia
Centex (US)	Acquired Fairclough Homes in 1999 (through its associated company, CDC). CDC is a master limited partnership created by Centex Corporation in 1987 to conduct real estate activities. In UK, CDC is involved in homebuilding
Pulte Homes (US)	Acquired builders in Puerto Rico in 1973.
KB Home (US)	Acquired a series of companies in France, beginning with Bati-Service, a major French developer of affordable homes in 1985, SMC Apartments in 1997, Euro Immobilier in 2003, and Groupe Avantis & Foncier Investiment in 2004

At times the surveyed companies operate through joint ventures; the motive however is not publicly disclosed. Companies like John Laing, George Wimpey, Barratt Development, Pulte Homes and KB Home tend to offer financing and mortgage service either on their own or with local partners to attract house buyers.

Table 5. Surveyed companies and their joint ventures

Company	Joint venture
George Wimpey (UK)	JV with Lennar Corp, the top tier & largest house builder in the US, for example, adult communities in Atlanta & Orlando
Taylor Woodrow (UK)	Example of joint venture development in Canada – Waterview Example of joint venture estate in Australia - at Landsdale, near Perth
Pulte Homes (US)	5 major JV developments in Mexico, 3 major JV developments in Puerto Rico
KB Home (US)	JV with Banque Indosuez in France

The overseas company can either be majority- or minority-owned by the surveyed companies. If the company is minority-owned, there is a possibility that the interest would be disposed, either gradually or at once, e.g. Taylor Woodrow and George Wimpey with their Australian operations, and Hovnanian Enterprise in Poland.

Some of the surveyed companies exited from the host markets, the reasons being:

1. To improve the company's returns. In January 2005, Pulte Homes disposed its Argentinean operation.
2. Focus on home operation. In 2002, John Laing partially disposed of its minority stake in WL Homes LLC to focus on home building operations in the UK.
3. Dispose of non-core/ non-performing assets. In 1999, after 3 years George Wimpey finally sold its company, Ardel, in Australia to local management to clear debt. In 2001, Taylor Woodrow sold its Australian company. Through the sale, Taylor Woodrow, gain profits from the disposal of the non-core asset.
4. Management buy-out. In 2004, the US management team for Barratt American Inc. approached the UK parent company to buy out the subsidiary after helping it return to profit.

CONCLUSION

This study looks at the international housing sector through the activities of Asia pacific region based developers and contrasted them with experiences from housing developers from the United Kingdom and United States. Changing demographics, liberalisation and housing reforms have been the primary factor that has destructured the once dormant housing markets of China, India and Vietnam, thus enabling housing developers from Malaysia, Indonesia, Singapore and Hong Kong to venture overseas to offer their expertise. Another useful outcome of this paper is the lessons and experiences that are being transferred to other developing country through the agency of foreign housing developers. It is timely that scholars recognize this emerging trend in developing countries so that they can then devote some time and energy to look into their progression and performance.

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The Effect of Leadership Styles on the Success of Construction Companies

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Abstract
A general director or leader of a construction company is one of its main assets. This work analyzes the reality of leadership style from three different and complementary approaches at the same time. This work is based on Goleman's proposal on different aspects of artificial intelligence; on J.W. Reddin's proposal where it is explained why leaders place achievement of results in the first term and above any one in the organization, or the other way round, and on how this response is faced dependent on style; and, lastly, on Maccoby's proposal that seeks a response on leadership styles from a leader's most profound personality: its family roots. This work brings to light that an analysis from Maccoby's approach may be used to predict the future of an organization more clearly as a function of its general director's leadership style. It may be also concluded that a leader is a person that avoids any manifestation of authoritarianism or authority earned in the organizational chart.

Keywords
Leader, style, management, construction, permanency.

INTRODUCTION

In developing economies, like that of Mexico, it is very common to see that construction companies fail before they make their first consolidation and before their first four years of life. There are many factors involved in the consolidation and permanency of a construction company, for example: its financing capital and high production equipment. Among them, perhaps the most important asset is the general director, the president, the CEO, owner or however it is fashionable to call him/her. Several articles agree on and reinforce this idea. Therefore, if a study to analyze said factors of success is to be made to be able to determine and define a successful company from an unsuccessful one, it would undoubtedly be specifically referring to its leader, the key factor in the success of any company.

This study analyzes who is at the head of construction companies in Jalisco, Mexico, which undoubtedly is very similar to other regions of the world under development. The study is based on the theories of three renowned authors: Daniel Goleman, W. J. Reddin, and Michael Maccoby. It is aimed to analyze the styles of directors from three different perspectives and therefore provide a more complete view on leadership styles. These theories are based on the following aspects: ***Goleman:*** to identify the different capabilities of the emotional intelligence that influence each leadership style; ***Reddin:*** specifies two criteria: individual primacy or task primacy of a leader's decision-making. ***Maccoby:*** discloses, under Freud's magnifying glass, the importance of early family relations projected by a leader, whether consciously or unconsciously, down to subordinates.

MANAGERIAL OR LEADERSHIP STYLES

Style may be defined as: "…a set of personal features " [Microsoft® Encarta® Consultation Library (2003)]. This is understood as a set of features that define what an individual really is in a single word. Is style chosen? No, it is not! Style is a series of amalgamated features of echoing experiences through the years; however, it is always possible to voluntarily influence and modify personal style. As mentioned in Hersey and Blanchard's article [Hersey, Paul and Blanchard, Kenneth H. (1981)], many writers agree that leadership is the "process of influencing the actions of an individual or group of individuals in an effort to attain a goal in a given situation" In other words, in any situation where someone is trying to influence the behavior of another individual or group of individuals, leadership is taking place. Furthermore, this definition truly agrees with that of the Real Academy of the Spanish Language, that defines a *Leader* as an Individual that is followed by a group of individuals that acknowledge him/her as chief or guide [Microsoft® Encarta® Consultation Library (2003)]. Formal leadership in construction companies is the topic under study in this work, specifically, that of the general director.

Once the terms *style* and *leader* have been defined, it may be understood that *Leadership Style* comprises an individual's features to influence the activities or thoughts of others. There are several theories that group studies on leadership by their similarities, this is why the study is focused on three different approaches to evaluate leadership styles of constructors in the area, with the purpose of analyzing them from different perspectives. Below is a brief description.

Goleman's emotional intelligence approach.

In his article "Leadership pays off" [Goleman, Daniel (2000)], Daniel Goleman presents six managerial styles identified after a research by the Hay/McBer consultancy firm, also based on the work of David Mc Cleland, renowned psychologist from Harvard. Goleman proposes that a director may choose his/her leadership style in terms of a specific circumstance and based on the six components of emotional intelligence. Goleman discusses that great leaders balance the alternative use of several styles with harmony. It should be considered that Goleman understands the concept of style not as something that features or defines a leader, but as a way or factor faced or handled thereby under different circumstances as a leader. According to Goleman's approach the styles are as follows:

Coercive ("Do what I tell you"): This is the least effective in most situations. It is a compelling and inflexible leadership style. A sense of fear develops. It despises both managers and subordinates. Decision-making always comes from the top, and subordinates feel that their work does not belong to them.

Authoritative ("come with me"): According to Goleman, this is the most effective style of the six, improving all climate variables. A visionary, a motivator with clear goals. Subordinates understand what their work is and are aware of why. A motivator of top commitment for the achievement of goals. Provides flexibility to subordinates so that they may find their own way, flexibility to innovate; experiment and take calculated risks. Establishes long-term vision.

Affiliative ("people are first"): Involved with people, appraises individuals and emotions above tasks and purposes. Makes effort to see that workers are happy and promotes harmony. Enhances flexibility, does not assess unnecessary restrictions and gives people freedom to perform their work. May allow uncorrected poor performance, workers may sense that mediocrity is tolerated. May leave group without guidance.

Democratic: Invests a lot of time obtaining ideas and support from people, fosters confidence, respect and commitment. Allows staff to participate in the decisions that affect their goals, increases flexibility and responsibility. Among the most negative consequences of this style are endless meetings; leadership is used to avoid making crucial decisions, and people are confused and lack a leader.

Pacesetter: Sets standards for extremely high performance and sets the example. Is obsessed with doing everything faster and better, and demands that everyone meets the criteria. If workers cannot perform as expected they are replaced. Destroys teamwork climate, Flexibility and responsibility disappear, there is no *feedback* on the work.

Coaching: Helps employees to identify strengths and weaknesses and links them to personal expectations and career. Encourages employees to set long-term goals and helps them make plans to achieve them. Provides plenty of guidance and *feedback*. Is at its best by delegating, gives challenging assignments and is willing to tolerate major short-term problems when it means lasting learning experience. Positive impact on climate and performance. The implicit message is “I believe in you, I bet on you, and I expect the best from you.”

Styles under the task or relationship orientation approach by W. J. Reddin [Reddin, W. J. (1990)]

This type is based on task orientation and relationships orientation dimensions and on leadership efficiency. The two basic managerial behavior elements are the task to be performed and relationships of people. Therefore, 4 basic styles have been developed: ***Separated:*** low task orientation and low relationship orientation. ***Related:*** low task orientation and high relationship orientation. ***Devoted:*** high task orientation and low relationship orientation. ***Integrated:*** high task orientation and high relationship orientation. Below is a synthetic description of each of the basic styles:

Separated: Concerned about correcting deviations. Tends to write rather than speak, there is scarce communication. Identifies with the organization rather than with its members. Concerned about rules and proceedings, and judges others based on performance degree. Avoids out-of-routine work. Corrects by enhancing controls. Hardly recognizes achievements, and undervalues the need for innovation.

Related: Accepts others as they are. Likes long conversations. Does not worry too much for time. Senses the organization as a social system. At the committee, supports others, harmonizes differences, guides and stimulates. Tends to not see mistakes and softens conflicts. When facing stress, tends to become independent and suffers from depression. Does not guide his/her subordinates. Fears conflicts.

Devoted: Tends to dominate. Gives oral instructions. Prefers "do-it-now". Identifies with superiors and with the company's technical system. Judges subordinates based on production. Active in meetings, initiates, evaluates and directs a lot. Subordinates learn fast that performance is what counts and punishment may be expected if there are mistakes. Conflict is suppressing and stress is dominant.

Integrated: Makes effort to mingle, uses meetings often for communication. Identifies with collaborators and enhances teamwork. Judges others in terms of teamwork. Active at meetings, sets standards and makes evaluations based on commitment and motivation. Employees are involved and committed by their intention to learn from mistakes rather than being punished for conflict.

Styles based on counter-transferences, by Michael Maccoby [Maccoby, Michael (2004)]

In his 30 years' experience as psychoanalyst, anthropologist and management consultant, Maccoby has found that *followers are so strongly impelled to follow as leaders are to lead*. The motives of followers fall into two categories: rational an irrational. Rationals are aware and are related with expectations of earning money, status, power, etc. But most of the time, they are influenced by irrational motives, for they flee from the conscious area and, therefore, from control. On the whole, these motives stem from powerful images and emotions of the unconscious mind. Sigmund Freud, the father of psychoanalysis, was the first person to provide an explanation on how a follower's unconscious motives worked. He realized that his patients idealized him, not because of his personal qualities but because they were related to him as if he were an important character from their past, usually a parent. Freud called this dynamics "transference". So followers project past experiences on their leader, and the leader responds by projecting his/her own experience on followers. Freud called this phenomenon *counter-transference*. This is the basis of leadership styles that are based on this theory. Leadership styles may be of three types: Father, Mother and/or Sibling, as explained below:

Father: Subordinates experience unconditional love for the leader, and slavishly waive their own visions to adopt those of the leader as unquestionably correct, the leader develops a willingness to obey orders on followers, the boss is overvalued and a childish desire for love and protection is strengthened. Some of them see him as mentor and others as demanding father who rarely gives his approval. This is the figure of a father smoking a pipe who produces small doses of encouragement, approval or constructive critique as necessary. He appears in paternalistic situations chairing big meetings, giving comforting, optimistic and reassuring messages, and projects the following message: "Trust me, I will lead you through troubled waters."

Mother: It is normally inspired in an earlier infancy relationship. The mother is seen as an authority figure and as someone who delivers unconditional love. She is protecting but also the first person who says "no". She raises feelings of amazement and fear on subordinates. They want their mother to be happy and proud of them, and feel profoundly guilty if they make her suffer. Maternal transferences can provide people with a powerful sense of support and many times a family-type culture develops in every company.

Sibling: Transference between siblings has increased influence as result of cultural changes of last generations, where children depend more on their siblings and friends for emotional support; they soon learn to play under their parents blame and to negotiate for privileges, which makes leadership more difficult. This type of transfer is more common in horizontal organizations. They are comfortable, interacting within their peers network, and establish independent relationships with some customers. They are independent and only need the boss as consultant or as part of the staff. Transference links are with their workmates rather than with their bosses, they work better as partakers in a game with roles, rules, rewards and clear relationships under an authority.

TOWARD AN INTEGRAL UNDERSTANDING OF LEADERSHIP APPROACHES

Goleman does not propose a *Style* in the deep sense of the term, but he presents the different features of a director's performance under specific circumstances: action, response. A leader moved by emotional intelligence provides a response with a series of features, in other words, a style; this is why Goleman proposes that success is the result of appropriate adjustment of style to given circumstances. This analysis requires that at least four styles are mastered in such a way that a general director's leadership style is the result of the degree of or combinations of specific styles. Goleman proposes an analysis of leadership styles based on performance. Reddin, based on his theory of task or individual, proposes that leadership should be analyzed as the sum of specific facts or performances that mark the trend to define "the" leadership style. Under Reddin's *integrated* concept, the leader is committed both to perform a task or obtain results and to employees. If these goals are not fulfilled, the *related* and *dedicated* styles come into action, the values hierarchy of a leader's education shows up, and either people are placed above the task or the task is placed above the people. This hierarchy has not been learned on a single day, besides, it may be modified, but based on the leader's commitment and efforts; however, where does a director's hierarchy or leadership come from?. Maccoby proposes a theory to explain style from the own roots of the human being, that is, from its early childhood, its environment, its family structure. Many times, the eldest child plays the role of the father before his/her younger siblings and this develops into a more authoritarian leadership style. Several children in a family will be more understanding and will be better mediators before their peers. It may not be inferred that there are bad theories and good theories, but that they complement each other. This study is intended to compare the degree of leadership related to results obtained by construction companies.

RESEARCH METHODOLOGY

This study considers construction companies in the State of Jalisco, México. The company directory supplied by the SIEM (Sistema de Informacion Empresarial Mexicano, www.siem.gob.mx/portalsiem/) has been used. SIEM is the largest public employer in Mexico, and runs the Ministry of Economy in Mexico. The universe of this study is comprised by 346 construction companies, and the sample size is 65 directors.

Only owners or company directors engaged in the construction business have been selected. Average interview time was forty minutes. This was a closed interview and no open commentaries by the interviewee were allowed. The interview contained 6 cases focused on daily aspects of the construction practice, where given situations were presented expecting different reactions or decisions from the director, so the interviewee would place the options in the order they fit his/her managerial style. Option number "1" was the one that mostly reflected his/her style. Each case presented a section of answers that corresponded each to the aforementioned leadership theories. And each answers included in sections means a determined leadership style. Thus, once the interviewee lists the answers of section 1, in case 1, he will be putting in order the leadership styles according to Goleman's theory [Orozco, Francisco (in progress)].

The director's leadership style preferences are reflected on a chart with numbers ranging from 1 to 6 for Goleman; from 1 to 4 for Reddin; and from 1 to 3 for Maccoby. These answers were given a weight to determine how they have influenced the result once we accumulate weights of each leadership styles. So, if the interviewee, in case 1, assigns "1" to the answer proper to the directive style called "Father", from Maccoby's theory, he will be accumulating 100 points in this style (see Table 1).

Table 1. Answer conversions according to cases

Goleman Conversion		Reddin Conversion		Maccoby Conversion	
Answer	Wt	Answer	Wt	Answer	Wt
1	100	1	100	1	100
2	75	2	65	2	55
3	40	3	30	3	0
4	25	4	0		
5	0				
6	0				

After converting answers into weights for each leadership style, the weights from the six cases were added and this condensed result was used to find which leadership style had the largest score for Goleman, Reddin and Maccoby. Hence, three leadership styles were determined for each director, as a product of the three theories.

ANALYSIS AND RESULTS

The construction companies in the sample have reflected that about a third of companies were founded less than 4 years ago; another third were founded 5 to 14 years ago, and the remaining third is comprised of companies whose permanency in the industry is over 14 years. Based on this analysis it has been determined that companies would be referred to as *young* companies (≤ 4 years), *medium* companies (> 4 and ≤ 14 years), and *mature* companies (> 14 years). This will show how changes in style versus company permanency are reflected.

Goleman's emotional intelligence theory approach

The director's leadership style of most of the construction companies in the sample is the *democratic* style, that is, decision-making is made by a team. This is the case for the three company cases under study, it must be emphasized that the trend of *mature* companies has had a significantly increase, moving up from 38% to 48% (see Table 2). In spite that the percentage of the *democratic* style is significantly greater, the increase of the *coaching* style is very important, moving up 13%. This contrasts a percentage decrease shown by the *affiliative* style (11%), and the *coercive* style, which is also decreased by 10%. It may be concluded that the more mature a company is, the more democratic and less coercive a leader is and the more willing to be a member of the work team.

Table 2. Style results based on Goleman

	Companies				Δ Young to
	Young	Medium	Mature	All	Mature
Coercive	10%	0%	0%	3%	-10%
Authoritative	19%	29%	22%	23%	3%
Affiliative	24%	29%	13%	22%	-11%
Democratic	38%	33%	48%	40%	10%
Pacesetting	5%	0%	0%	2%	-5%
Coaching	5%	10%	17%	11%	13%
Totals	100%	100%	100%	100%	

W. J. Reddin's approach to task or relations

A strong predominance may be observed on the *integrated* style from other leadership styles, nonetheless, it is perfectly clear that the second place is, by large, that of a *related* style (see Table 3). It is particularly important, as the industry is analyzed, to see that the results suggest that relationship of permanent companies is more important than results or tasks, particularly because the industry is a large capital consumer. Reddin's analysis may be used to differentiate companies that manage to stay from companies that do not, because results are homogenous for the three types of companies (see Δ on Table 3).

Table 3. Style results based on Reddin

	Company				Δ Young to
	Young	Medium	Mature	All	Mature
Separated	0%	0%	0%	0%	0%
Related	33%	24%	35%	31%	1%
Dedicated	0%	5%	4%	3%	4%
Integrated	67%	71%	61%	66%	-6%
Totals	100%	100%	100%	100%	

Michael Maccoby's counter-transference approach

The results for young companies are very homogenous. It may be noticed that the *father* counter-transference style is the same as the *sibling* style, and mature companies are 10% for the *father* style and 70% for the *sibling* style (see Table 4), this is the most meaningful difference in the whole study, it allows to infer that permanent companies in the industry are lead by people whose leadership style falls in the counter-transference *sibling* style.

Table 4. Style results based on Maccoby

	Companies				Δ Young to
	Young	Medium	Mature	All	Mature
Father	38%	10%	17%	22%	-21%
Mother	24%	19%	13%	18%	-11%
Sibling	38%	71%	70%	60%	31%
Totals	100%	100%	100%	100%	

This result is much more meaningful because the real trend of organizations is characterized by scarce hierarchy and where the prevailing management as "equals" happens in more horizontal organizations. Maccoby's theory has opened another avenue into another area of vital importance in the future: data from family-related environment. The family concept is under crisis in most communities, and results provide clues that cannot be neglected; for example, see the amounts of siblings of leaders on Table 5.

Table 5. Position of a leader as a sibling

	Companies				Δ Young to
	Young	Medium	Mature	All	Mature
Single	0%	6%	0%	2%	0%
Younger	8%	17%	23%	17%	14%
Middle	67%	61%	73%	67%	6%
Older	25%	17%	5%	13%	-20%
Totals	100%	100%	100%	100%	

These results show that only 2% of directors of construction companies are single children, this information speaks of the relevance of family mechanics. The family, therefore, seems to be a determinant: the first organization where man learns to manage or lead. Another meaningful result is the number of siblings of leaders in the construction industry in Jalisco. The more mature a company is, the more siblings a leader has (see Table 6).

Table 6. Children in a director's family

	Companies			
	Young	Medium	Mature	Average
Average siblings	2.25	2.50	2.91	2.62
Top	4.00	6.00	5.00	5.00
Bottom	1.00	1.00	1.00	1.00
Standard Deviation	0.97	1.33	1.49	

CONCLUSION

To carry out an analysis related to managerial or leadership styles, the ability of people to influence others for the achievement of results, not only is it necessary to make a study of isolated cases or a synthesis thereof in the form of a general style, which may have a trend toward tasks or relations, but it is also necessary to dig deep down into the own roots of a director's personality.

It may be concluded that a leader is a person that avoids any manifestation of authoritarianism or authority earned in the organization chart, as suggested by the three analyses above. Goleman shows 3% for the *coercive* style from the total sample and 0% for mature companies; based on J.W. Reddin's *separated* style, it is zero for the three company levels; and according to Maccoby's theory, it is shown that the *father* and *mother* styles hold a larger authoritarian component, with a lower number of incidences. The most important feature of a leader is the ability to relate with subordinates. According to Goleman, the *democratic* style was not the only one to reflect the highest percentage (40%), but also the only one to be markedly higher for mature companies; in a way, a leader who is mostly integrated to Reddin's theory also shows these relationship features in a more markedly way than task features; and Maccoby's approach arrives to the sibling concept as a leader who sees others as equals or peers.

From the results of the above approaches, it may be inferred that an analysis from Maccoby's approach may be used to predict the future of an organization more clearly as a function of its general director's leadership style.

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The State of Repair of Buildings in Akure, Nigeria

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Abstract
This paper appraises the state of repair of buildings in Akure, Nigeria. The paper reports findings from a research conducted by the author. The objectives of the study include the examination of the material characteristics of the buildings, and the examination of the variables that impinge on their quality. A research instrument was designed to elicit data. The city was stratified into twelve, and in each stratum a sample of 50 cases was selected by the systematic sampling technique. Research findings show that the state of repair of most buildings was poor, as these require major repairs to make them sound. Furthermore, out of the twelve independent variables investigated, only eight significantly explained residual variation in the dependent variable (the state of repair of the buildings). These are *AMNT* (amenities), *HHSZ* (household size), *NOBD* (number of bedrooms), *FLOO* (floor finish), *AGE* (age of building), *MODCON* (mode of construction), *WALL* (materials for wall), and *TENR* (type of tenure). A linear model was developed for predicting the state of repair of buildings in the study area. This is an aid to concerned parties, especially practitioners in the construction industry, to identify variables that are cogent in predicting building quality.

Keywords
Building, quality, repair, state, variables

INTRODUCTION

The quality of housing and the environment is of great concern in Nigeria, as in most Less Developed Countries (LDCs). This is indicative, in part, by the state of repair of buildings in both the rural and urban centres. The state of repair of buildings is a crucial determinant of the habitability of buildings, which in sum informs the level of comfort, satisfaction, security and safety of the residents. The deterioration of the conditions of urban buildings in Nigeria is a direct consequence of the rapid rate of urbanisation it is experiencing. The rapid rate of urbanisation has resulted mainly from a high rate of rural-urban migration and the increase in the number of concentration points in the urban centres. Studies have shown that this has exacerbated the deterioration of living conditions in Nigerian urban centres and had exerted untold stress on existing housing stock, public goods and services and basic infrastructure (Diogu, 2002). This has led to a general degradation of the environment manifesting in the growth of slum conditions in the urban centres. (Mabogunje et al 1978; Jagun; 1983, Olotuah, 1997; Olotuah, 2000).

The excruciating problems of housing poverty as characterized by poor building conditions and overcrowding in existing housing stock is symptomatic of the high magnitude of housing needs in Nigeria, which is increasing by the day. The Nigerian government and the private sector have been unable to meet the housing needs of the populace. There is acute housing shortage in the country, especially in the urban centres, because the provision of housing has never really matched the country's population growth (Olotuah, 2002). Concomitant with this is the low economic capacity of most urban households owing to a depressed economy and unequal income distribution. The deplorable quality of housing in Nigeria is reflected in the predominance of structurally unsound and substandard houses (Onokerhoraye, 1976;Wahab et al 1990).

RESEARCH METHODOLOGY

This paper reports a research conducted by the author on housing studies in Akure, the capital city of Ondo State Nigeria. The objectives of the research include:
(i) The examination of socio-economic variables that impinge on housing quality;
(ii) The examination of the material characteristics of the buildings; and
(iii) The appraisal of the provision and performance of public infrastructure and social services provided on community basis.

Primary data for the research were obtained in a field survey conducted in the study area, Akure the capital city of Ondo State, Nigeria. The research instrument used was a well-structured questionnaire, which was designed to elicit data on housing issues pertinent to the study. A data matrix of 30 variables by 600 cases was adopted for the research, which yielded 18000 responses. The questionnaire was written in English Language, the Nigerian Lingua Franca. The observed outcome of the variables constituted the data for the research.

The questionnaires were administered by final year, B Tech Architecture students of the Federal University of Technology Akure, Nigeria. The author had earlier tutored them on the procedures and the modalities for the exercise, which he also supervised and monitored it. The samples (600) were selected by the stratified random sampling technique taking care to ensure that they were fully representative of the population of the study. The study area was divided into twelve zones (strata) following the historical evolution of the city. In each zone 50 cases were picked randomly.

A questionnaire only was administered in a building since most of the variables measure the physical attributes of the buildings. Household heads were usually chosen as the respondents and in instances when they were not literate in English Language the questionnaire was translated into Yoruba, the local tongue spoken in the study area. The questionnaires were retrieved immediately after completion and collated for analysis.

Descriptive summary measures were calculated for each of the variables under investigation. The univarite analysis conducted also includes frequency distribution for the variables. Multiple regression analysis was also conducted on the research data. The various analyses were performed with SPSS (Statistical Package for Social Sciences) Version 10 computer program.

RESEARCH FINDINGS

The data obtained show that 13% of buildings in the study area were constructed over fifty years ago. These were mainly concentrated in the core areas (inner-city neighbourhoods) of the city. Forty percent (40%) of the buildings in the study area were constructed in the last two decades (Table 1).

Table 1. Age of buildings

Age	Percentage
1 –10	10.0
11 – 20	30.0
21 – 30	28.3
31 – 50	18.8
Above 50	12.9

Source: Fieldwork, 2004

Close on half (47.5%) of the buildings were rooming houses, with two rows of rooms that face each other, and a hall between them. Apartment buildings on one floor, as single-family and semi-detached units, constitute 30% of the buildings. The average number of households in a building was 4, while the average number of bedrooms in a building was 5. The frequency distribution analysis showed that in most cases the number of bedrooms was 6 (mode of the distribution). The average household size was found to be 7.

The research data indicate that only 26% of the population was owner-occupiers. Those that lived in family houses were one-fifth of the population, while the majority, constituting 54.2%, rented their dwelling units (Table 2).

Table 2.Type of tenure

Age	Percentage
Owner-occupied	25.8
Rented	54.2
Privately Owned (family)	20.0

Source: Fieldwork, 2004

Most of the buildings in the study area were connected to the public electricity mains. Electricity supply was however epileptic and was only available to the majority of the buildings between 6 and 12 hours a day.

Most buildings (40%) relied on hand-dug wells for water supply. The wells often dried up during the dry season (October-February), and were only reliable for supply during the rainy season. About one-third of the population obtained water from tanker service, while water from public mains was available to one fifth. In 8% of the cases studied, water supply was not available, and the residents had to resort to nearby streams or turn to their neighbours (Table 3).

Water closets (WC) were in half of the cases studied. In 45% of them were pit latrines, and the remaining 5% did not have any toilets at all. Kitchen, as separate rooms within the building, were available in 52% of the buildings. In 39% of the cases the kitchens were detached from the main buildings, located at the rear, and built of wooden planks. In about a tenth of the cases the

inhabitants prepared their meals in the corridors, (halls between the two rows of buildings in the rooming houses).
In the survey the physical conditions of the buildings were investigated. The buildings that were dilapidated were less than 2%. These were buildings that had severe cracks on walls, falling or leaking roofs, and in some cases were sinking into the ground where excessive flooding had taken place. They were considered unfit for habitation. Close to two-thirds of the buildings (60%) required major repairs to be effected to bring them to normative and structural quality. These too were unsafe for the inhabitants, and clearly constituted an affront to human dignity. About a third of the buildings (29%) required minor repairs, while the remaining 9% were good enough to be regarded as sound (Table 4).

Table 3. Water supply

Age	Percentage
Well	40.4
Tanker Service	29.6
Bore Hole	2.5
Pipe Borne in building	14.1
Public Tap	5.4
None	8.0

Source: Fieldwork, 2004

Table 4. State of repair

Age	Percentage
Dilapidated	1.8
Require major repair	60.4
Require minor repair	29.2
Sound	8.6

Source: Fieldwork, 2004

In the evaluation of the conditions of the buildings the influence of the variables individually and collectively in predicting their state of repairs was investigated using the multiple regression analysis technique. Twelve variables were entered on forced entry as independent variables (Table 5).

Table 5. Specification of variables

S/No	Name	Code
1	Age of Building	AGE
2	Number of Households in a building	HHNO
3	Number of Bedrooms in a building	NOBD
4	Household Size	HHSZ
5	Amenities	AMNT
6	Walling Material	WALL
7	Type of Tenure	TENR
8	Floor Finish	FLOO
Mode of Construction	MODCON	
10	Roof Covering	ROOF
11	Window Type	WIND
12	Income Stratification	INCM

Source: Research Design, 2004.

The dependent variable in the model was the *State Of Repair* of the buildings. The coefficient of determination (R^2) of the model was 0.826, which indicates that the independent variables collectively explain 82.6% of the residual variations in the dependent variable. However only eight of the variables (*AMNT, HHSZ, HOBD, FLOO, AGE, MODCN, WALL, TENR*) show significant contribution to the explanation of the residual variation in the dependent variable.

In order to obtain the equation of best regression, the step-wise algorithm was carried out with the variables being entered according to their contribution to the model. The analysis of variance shows that in each step of the model the contribution of the variables was significant with a steady increase in the coefficient of determination and decrease in the standard error of the estimate. The eight variables in the model are consequently the predictor or explanatory variables for the *State Of Repair* of the buildings. The least-square algorithms applied to the model

$$\hat{Y} = \beta_o + \beta_1 \, AMNT + \beta_2 \, NOBD + \beta_3 \, HHSZ + \beta_4 \, AGE + \beta_5 \, WALL + \beta_6 \, TENR + \beta_7 \, MODCON + \beta_8 \, \mathrm{FLOO} + \mathrm{E}$$

(Where $\hat{Y}$ - dependent variable, β_o – constant, $\beta_1 \ldots \beta_8$ – regression coefficients of predictor variables E – error component in the model) gives the estimated equation of the model

POLICY IMPLICATIONS AND RECOMMENDATIONS

Most buildings in the study area were deficient in the provision of amenities (electricity, water supply, toilet facilities) to make them habitable. The structural condition of most of the buildings was poor and they were thus unsafe. The poor provision of toilet facilities constituted a threat to the health of the inhabitants. The lack of adequate water supply and the high rate of use of available toilets place the buildings in perpetual insanitary conditions. Most of the buildings thus severely pose a threat to the lives of their occupants.

The intervention of the public sector is imperative in salvaging the poor conditions of housing in the study area. The Nigerian government has over the years shown its commitment in ensuring access to adequate housing by all Nigerians (FGN, 2004). It has a responsibility in ensuring housing standards (sanitation, space, materials of construction) and this it should brace up to in order to improve the standard of living of the population, and hence their productivity.

The poor conditions of buildings, and their rapid deterioration are symptomatic of severe shortages in the study area. The intervention of the public sector is required in meeting the housing needs of the population through stimulating and sensitizing the private sector, and direct house construction for the poor.

An enabling environment should be created for the private sector to operate optimally in housing provision. The problems the private sector contend with in the provision of housing include difficulties in obtaining planning and building permissions, inadequate access to housing finance, high cost of urban land, and lack of access to urban services and infrastructure (Olotuah, 2005).

Urban renewal programmes are required to rehabilitate, renovate and redevelop the existing housing stock in the study area. Government should vigorously pursue slum improvement. Total clearance involving building demolition should be avoided, while renewal strategies to prevent slum formation should be devised.

CONCLUSION

The state of repair of buildings in Akure, the capital city of Ondo State, Nigeria is examined in this paper. Most of the buildings require major repairs to make them habitable and safe. The quality of housing in the study area is found to be poor and thus requires urgent attention. The public sector is suitably placed to ensure this through an effective housing programme, and urban renewal scheme. The programme should involve direct construction of low-cost houses for the poor, and an enabling environment for improved performance by the private sector in housing provision.

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The Artificial Hill: a matrix project, a low-cost and high quality habitat for a metropolitan area

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Abstract
The article reports a research study started at the Polytechnic of Turin in the 90's. It combines various topics from house type and innovative technologies to appropriate strategies for building design and construction in developing countries. It was aimed at making quality housing accessible to the poor.
The starting point of the research study was twofold: the workplace is always far from the houses of low income people and the high costs of land and building constructions in the formal sector of mega-cities are not accessible to the urban poor. The research proposes
a. strategies to create a partnership among local residents, political authorities, investors and developers, and municipal technical officers
b. appropriate and hybrid technologies, alternative energies, low energy materials, electronic technology
c. a house typology that combines residence, facilities and production activities compatible with housing.

The envisaged solution was named the "Artificial Hill". It would bring a reduction of building costs, social costs and infrastructure costs.
The Artificial Hill builds up its own model on the basis of technological assumptions that combine tradition and modernity, innovation and tradition, and poor and high technology.

Keywords
Low-cost, urban habitat, Artificial hill, "green" housing, hybrid technologies

BACKGROUND

The urban habitat, the less well-off and the research objectives

The megalopolises of developing countries evidence the inadmissibility of the extensive habitat - i.e. the so-called horizontal city - due to the very high costs of land. On the other hand, poorer habitats develop horizontally only, due to the inaccessibility of multi-storeys as they use evolved technology.

The cost of land is very high in the megalopolises and the costs of transport relative to an extensive city are not affordable for the urban poor. In fact, such conditions are present in both developing countries and in the large cities of the industrialised world.

The objective of the research study consists of identifying, localising and characterising a housing and building model of urban typology and morphology, such that advantages and interests can be developed by poor users, urban administrations and the private sector – in other words an influential partnership.

This research study was developed within a "finalised project" of the Consiglio Nazionale delle Ricerche (CNR) entitled "Quality and building innovation" and published in 1995 [Minervini, 1995]. The themes tackled during the research study were both many and multi-faceted: high density, low residential cost, appropriate hybrid technologies, composite technologies and "green" technologies.

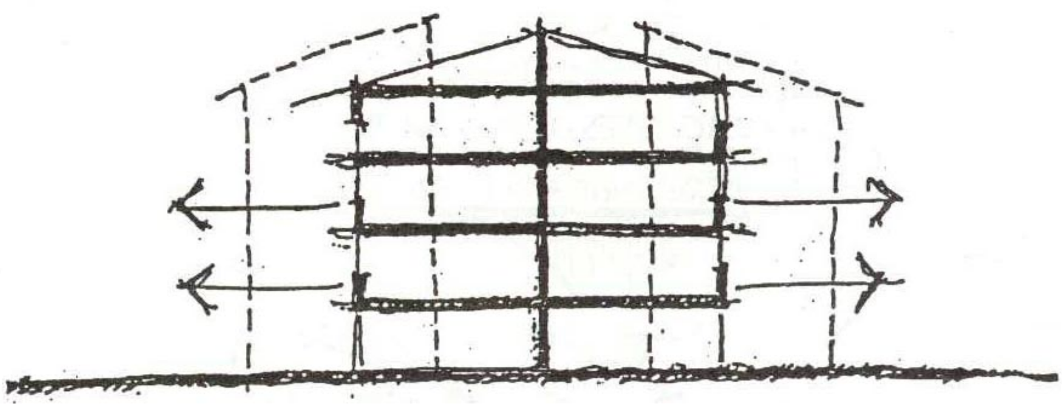
The building typology: from the "sandwich" to the "hill"

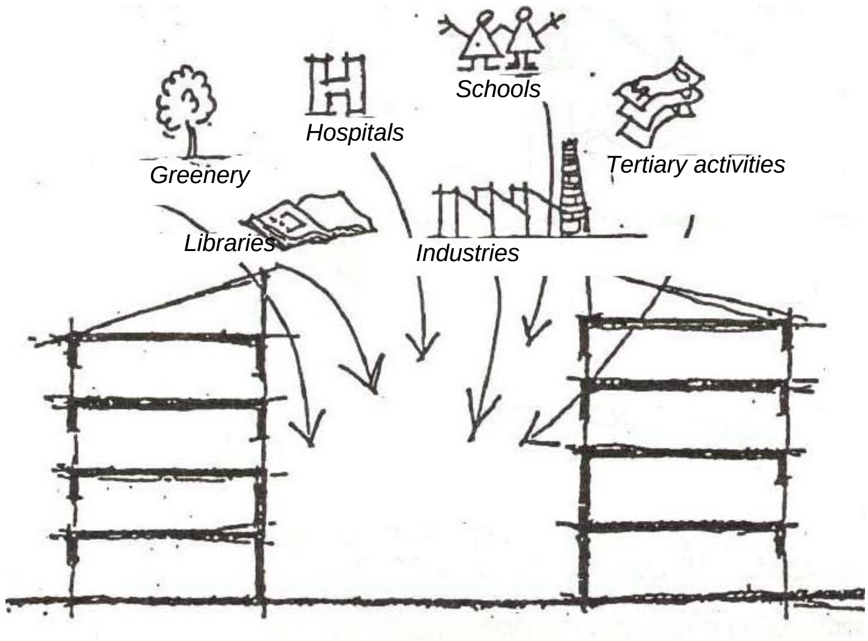
The fulcrum of the entire research study was placed on a building typology defined as the "sandwich", from which a new - but conceptually similar typology - was then developed, the so-called "Artificial Hill." These are project matrixes and not specific concrete projects, which in reality would be difficult to express without contextualization, which is an indispensable condition for building and not for imagining.

The "sandwich" building typology does in fact constitute the basic idea for the entire research study and the related design elaboration. It consists of a building block characterised by residential functions on the outside, and services and/or small or micro production activities that are compatible with residence in the inside. In reality, the concept takes up again and develops Habraken's theories concerning the three vocational bands of a building construction.

The "Artificial Hill" building typology puts forward the above "sandwich" concept again but applies it to a hyperbolic (mega) structural model, as localisation in a third-world megalopolis was assumed.

Fig. 1 Generation of the "sandwich" building typology





THE ARTIFICIAL HILL

The "artificial hill" consists of a high constructional and housing density mega structure around which are drawn complex, composite and hybrid technologies. These were specially designed to reduce production and maintenance costs, while at the same time maintaining high building quality and residential quality. "Green" technologies were studied and applied to respond to housing poverty firstly, and to the consequent need and great desire of standard users (ascertained in high density residential buildings) to experience:

- their own individuality i.e. to not wish to be conditioned or disturbed by the freedom expressed by neighbours
- contact with nature.

The Artificial Hill has attempted to provide a response

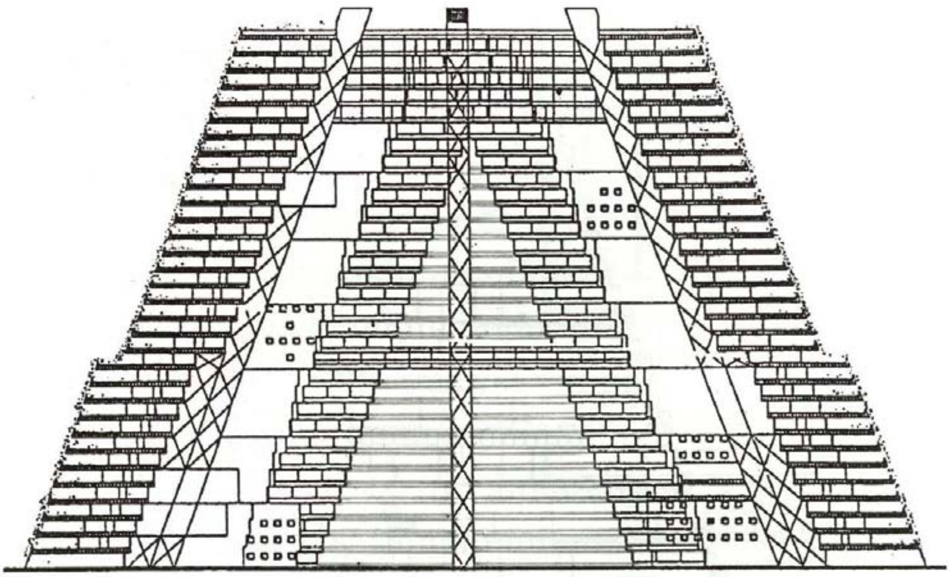
1. to the generalised desire for a detached house (isolated and green)
2. to the low cost requirement
3. to the need to live as close as possible to the workplace.

As a matter of fact, these are the three conditions which unauthorised constructions and slums also attempt to satisfy, particularly in the megalopolises of the third world.

The Functions

The "Artificial Hill" was designed as a "skin" destined for as a residence that is highly integrated with nature, and with a "core" occupied by services, small-scale production systems (sustainable and compatible with residence), shops, craft and cultural activities. These "internal" functions were attributed with the potential to absorb the maintenance costs of the structure and the running of the main systems. Indeed, "blind" buildings - i.e. buildings without a view - are very widespread nowadays, and used above all to perform functions such as car-ports, banks, hypermarkets, catering facilities, sports premises and cinemas, non-polluting small-scale production, retail activities, and craft and other activities with an absolute need for contact with the pedestrian streets and no need for direct sun light.

Fig. 2 The “Artificial hill”: a possible model



The visible habitat generated by the Artificial Hill is an integrated habitat of residences on the outside fronts, while the inner core of services and small production activities are able to shoulder the cost of the former.

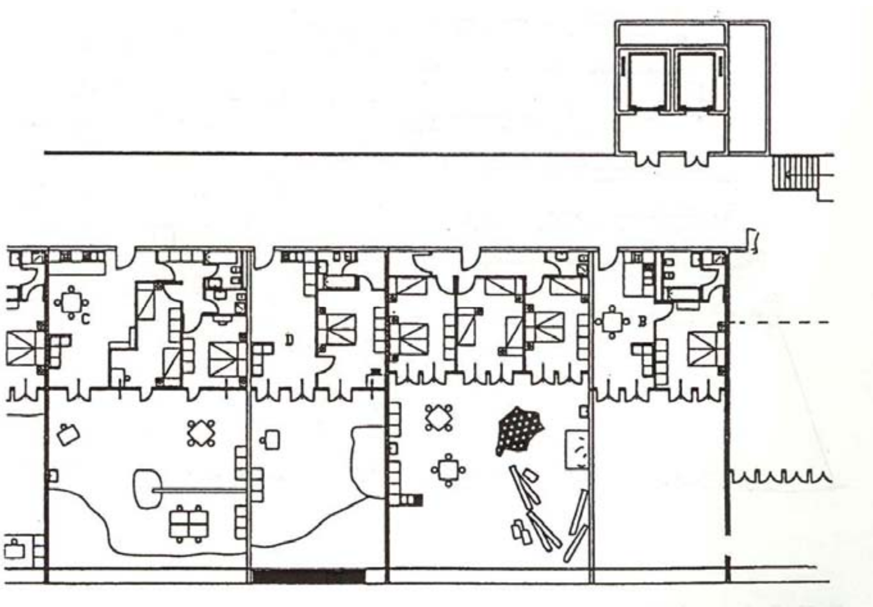
The need to reduce land occupancy as much as possible mainly for financial reasons has already been introduced into a great diversity of cultures, with the possibility of having activities which are carried out in totally confined areas, precisely such as hypermarkets which go three storeys underground, car-parks and gyms etc.
The use of the hill’s internal volume for services and activities which do not have an effective necessity for a view to the outside and the street level, allows the following, in addition to land cost savings:
- savings in infrastructure costs)
- saving on the structure cost since it is shared with the residence.

Furthermore, as the inside volumes are not exposed to outside stresses (such as the wind or the elements in general), the saving on insulation, damp-proofing and maintenance costs for it become considerable. This saving compensates for the increased cost of the supporting structures due to the greater load.

To conclude, the presence of these production and service structures leads to a consequence, which becomes strategic in the reduction of housing costs, so much that we may affirm that the cost of the volumes inside the “hill” can reasonably sustain the building costs and main infrastructure costs, thus freeing the residence from the burden of these costs.
The implications of these affirmations from the urban policy and strategy point of view are significant, as
1. horizons would be opened up for resolving the age-old problem of slums
2. a further option would be opened up regarding Social Housing strategies.

On the “Skin” of the Hill
Building with terracing is a practice, strongly requested by urban residents. There are examples of it throughout the world.

Fig. 3 Planimetric studies of housing types on the "skin" of the Hill



In the specific case of the hill, the flats are located on the "skin" and have a partially covered terrace. The terrace is a natural extension of the home, and at the same time a rather significant element in satisfying users' requirements and in increasing the residential quality. Moreover, particularly in countries with a tropical climate, the terrace (i.e. the area outside the home) would lend itself to be used for the carrying out of typically residential activities.

As a result, the external surface area of the "hill" may also be considered exploited. In fact, the "hill" becomes rich in functions and therefore "artificial" rather than natural. The residential habitat (with its own very peculiar characteristics such as the carrying out of part of the residential functions) is reproduced vertically and not horizontally, while attempting to maintain the advantages of the horizontal habitat.

In the "belly" of the Hill
Production and services flows run through the belly of the hill, but also equipment and information for the control of the consumption and running of the entire complex structure and the supply of services to the building and the flats.
More specifically, the hill's wiring includes high tech apparatus for the remote control and monitoring of both the structure and the systems, allowing very great reductions in consumption - as is typical of this apparatus which can manage electricity consumption, cooling and heating and the control of the air quality and smoke as a fire risk etc.

The following can be applied alongside the state-of-the-art electronic technologies: bio-climatic passive control systems, solar energy exploitation systems, a mirror system to return sun rays inwards, and dissipated energy recovery techniques to make the vertical connection apparatus or the air-conditioning systems function.
As the hill is a mega structure with 2000 inhabitants on approximately one hectare of land, the control of what does not take place during daylight hours is an issue. Research in this regard has fine-tuned control systems that make use of surveillance cameras and monitors (which are now

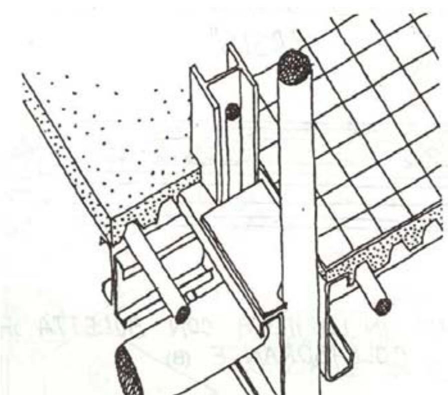
available at gradually decreasing costs) that make a concentrated residence complex of this type more secure.

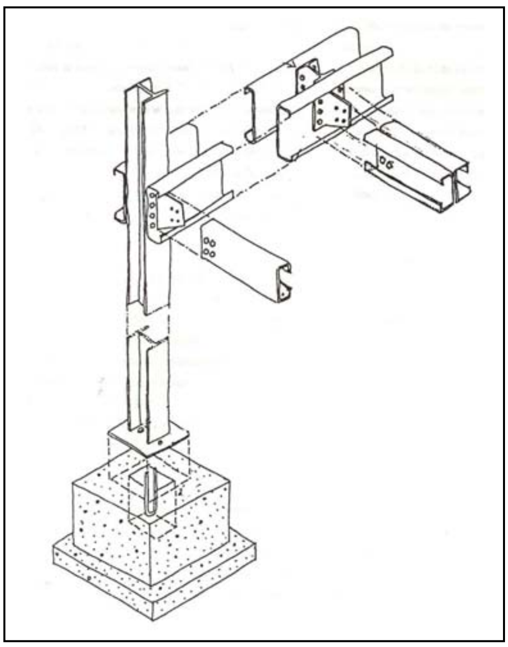
Building Technologies, Material Technologies and Information Technologies

The hypothesis on which the "Artificial Hill" was built consists of a "cage-type" structural system in steel with terraces, with a trapezoidal section. The choice of the steel structural cage was essentially due its good resistance/weight ratio, the adaptability and modularity of the structure, ease of maintenance and inexpensiveness. The system adopted is a versatile prefabricated system that is easy to erect and has flexible, repetitive distributional layouts, which are alterable and expandable. The choice of this structural type is also due to the fact that the most appropriate planning hypothesis for the hill focuses on steel in state-of-the-art alloys, for which the development of the research study results in acceptable costs, high resistances, zero maintenance, very low expansion and good fire resistance etc.

However, the structural body of the "Artificial Hill" is not the steel cage but rather the technology itself, which seeks, articulates and unites materials such as titanium alloys with ordinary and very plain materials such as stabilised soil. The technological abacus, which the hill exploits also, constitutes newly tested hybrid and composite materials such as plaster and sisal, glues and vegetable material residues. In this way, building, structural and completion components such as undulated and non-undulated sheets for roofing, infills and flooring with rice straw and polyester resin mats, and beams from reject items (wood shavings, sawdust and branches) put together and pressed with resins, result in low production costs and require only non-specialised labour due to the moderate technological content process. Moreover, green technologies complete the technological abacus of the hill and were studied because of the numerous advantages which can result from the use of the building system for the inside: reduction in noise pollution, dust filter functions, and improved air quality and mental life. Green roofing and infills ensure the structures have fewer thermal and mechanical stresses, better heat insulation and lightening of the water disposal system, and above all they allow user access to the building process.
In this connection, Ferro cement roofing and Ferro cement panels have been studied. They are easy to process and lay as they are thin and light, and are appropriately covered in vegetable materials. The association of the two types of material provides good results in terms of thermal comfort, self-building and self-maintenance.

Fig. 4 Structural Elements of the "sandwich" and the "hill"





Last but not least, telematics. The research study individuated different sectors in which telematics can give the "Artificial Hill" the following:

- structural monitoring to control that none of the important parts of the supporting structure forming the hill exceed the stresses and deformations considered acceptable
- control of the corrosion situation of the different structures, again to ensure safety
- monitoring of temperatures to warn of the outbreak of fire in time and to activate fire-prevention measures
- the running of the elevation, air-conditioning, ventilation and waste disposal services etc., makes the hill similar to an intelligent building and allows the use of elements and resources which would otherwise be wasted - from the energy employed inside the building (use can be made of that part of the energy which would be lost) to the chimney effect, the greenhouse effect and the picking-up and directing of solar and light energy etc.
- control systems and anti-intrusion security systems, systems to control unacceptable behaviour in the public areas, for the elimination of queues for waiting for vertical or horizontal transport, re-directing users or means of transport
- regulation of the mobile elements of the building, from doors to movable walls, sun-blinds, and variable absorption window-panes etc., this considerably helping the building to meet the variable needs of users.

The Cost

During the research study a comparative analysis of the total costs of an artificial hill was also conducted, comparing them with an urban system (mainly developed horizontally) with the same field conditions, functions, services and inhabitants. The comparative analysis of the costs considered the costs of land, the building cost and the planning, urbanisation and construction charges.
The "Artificial Hill" signifies an immediate 50% cost reduction. In detail, it is found that the special rearrangement (lay-out) of the functions from horizontal to vertical signifies a reduction in building costs (approximately 9%), charges (10%) and land (80%).
Clearly, due to the typological particularity of the hill, exception agreements would be necessary at the resolution of the plan (if the plan were already approved), as well as close co-operation between the various actors involved in this remarkable property operation which implies a residential density of 2000 residents per hectare and a building density of more than 400,000 cubic metres per hectare. Entrepreneurs and local government institutions, residents' associations and other groups would all be involved in a far-reaching operation with economic and financial operations starting from the very first planning stages.

SUMMARY OF THE CHARACTERISTICS OF THE "ARTIFICIAL HILL"

The "Artificial Hill" is not a project, but rather the fusion of different studies and research into low cost housing, hybrid and composite technologies, aided self-construction and shared planning. It is therefore a matrix of building and urban projects for developing countries, of which the main characteristics are listed below:

- reduction in costs of acquisition of buildable land
- reduction of infrastructure costs due to high residential density
- participation of the production and services parties in the realisation of artificial land on which to build the housing units
- workplace proximity
- response to the need for developmental habitat

- response to the need for open green areas for climatic and economic reasons (cultivation of small vegetable gardens)
- opportunity to include users in self-building of their home
- integration of residence, services and compatible production structures
- a variety of forms and sizes, from small basic units to buildings with several storeys
- social mixing: homes for the weak brackets and medium-to-high standards of homes
- systematic use of nature as a building element to increase global quality
- reduction in energy consumption thanks to heat stability, due to the large size which enormously reduces the need for cooling and heating
- technological mixing: steel supporting structures and conventional industrialised technologies for services, hybrid technologies for low cost residences (lamellar wood made from timber waste for small structural elements, plaster composites and vegetable fibres for partitions, resin and sheet mats for lightweight roofing of open areas)
- use of information and telematic technologies made possible by the low cost tendency of basic components
- possibility of performance and public order control with the use of information and telematic technologies
- personalisation of the home.

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Analysis of Building Regulations in a Changing Climate. Methodology and Case Study.

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Abstract
One of the most cited adaptation measures to climate change in the literature is the revision of building regulations and voluntary building codes since current constructed buildings will be kept on when the most serious impacts of climate change begin to be evident. The main objective of this paper is to establish a methodology in order to assess the level of adjustment of those thermal building regulations to the new conditions imposed by the climate change. The methodology exposed in this paper will allow the analysis of thermal building regulations in any country taking into account the expected evolution of the temperature due to climate change. To verify the methodology, current Spanish thermal building regulation has been analysed and its level of adjustment to the future climatic context has been assessed.

Keywords
Climate change, adaptation strategies, building regulations, Spain.

INTRODUCTION

Recent observed trends in climate and recent observed extreme events are lending importance to climate change in the entire world. In addition, the envisaged climate changes due to global warm over the next 50 years. It suggests important changes in mean and extreme values of temperature, precipitation and wind. The full range of the impacts resulting from these changes is still uncertain; however, it is becoming increasingly clear that adaptation to climate change is necessary and inevitable within several sectors [Lisø *et al*., (2003)]. Adaptation to climate change can be described as adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities [McCarthy *et al*., (2001)].

The expected life span of many new and existing buildings (from 60 to more than 100 years) means that the building stock of the future consists of the today's building stock and of new construction. In the future, part of the present building stock will be adapted to changes in the environment, while the rest will be kept as they were designed. Bearing in mind this context, one of the most cited adaptation measures to climate change in the literature is the revision of building regulations and voluntary building codes. Lowe 2004 states that "It is increasingly obvious that a range of different mechanisms will be required to address the problems of adapting to climate change. Options include regulation, financial instruments, market forces, provision of information and exhortation". According to Hasegawa, 2004, in general, building regulation is the instrument that makes building reach predetermined levels of performance in the most certain way if they are effectively enforced and should play a significant role in adaptation. Larsson 2003 adds that maintaining or improving operating energy performance requirements of new and existing buildings through regulation constitutes a measure that will serve both adaptation and mitigation efforts.

The main research objective in this paper was establishing a simple but reliable methodology that would allow the assessment of the level of adjustment of those thermal building regulations to the new conditions imposed by the climate change. Despite climate change being a planetary phenomenon, the potential impacts, and subsequent human adaptative action, differ across countries and climatic zones. For this reason, a case study based on the Spanish thermal building regulation is exposed in this paper in order to validate the methodology.

METHODOLOGY

In order to assess the level of adjustment of thermal building regulations to the new conditions imposed by the climate change, a four-step methodology is proposed:

Step 1: Analysis of temperature influence into thermal building regulations.
Bearing in mind the particularities of construction regulations in each country, influence of temperature into thermal building regulations must be carefully studied. In most European countries, these regulations define several numbers of climatic zones depending on its degree days (parameter which is a measurement of the severity of the climate). Other countries limit themselves to one climatic zone in spite of the relatively large variation among the degree day figures in their territory. Minimum or maximum mean temperatures for a certain period of time can also be included in thermal regulations.

Step 2: Analysis of recent observed trends in temperature during the 20th Century.
Recent tendencies of temperature in a national scale during the 20th Century must be analysed. Data should be translated according to its processing in the thermal regulation. As stated, one of the most used indexes in thermal regulations is degree days figures. This parameter can be calculated as the addition, for every day of a certain period of time, of the difference between a fixed temperature (normally 15ºC or 20ºC) and the mean daily temperature, when this daily temperature is lower than the fixed temperature. In order to simplify, we can accept that the monthly mean temperature can represent daily mean temperature. As minimum or maximum mean temperatures for a certain period of time can be included in thermal regulations, its trend during the 20th Century must be also analysed.

Step 3: Establishment of climate change scenarios over the next 50 years in order to assess the likely changes in temperature values in a national scale.
Envisaged climate conditions must be taken into account in order to assess the level of adjustment of thermal building regulations related with climatic variables. In order to make projections of the climate change, global climate models are currently used. Obviously, these models are forced with evolutions of the levels of greenhouse gasses and aerosols accumulated in the atmosphere. These predicted evolutions are synthesized under four scenarios (A1, A2, B1 and B2) in the Special Report on Emissions Scenarios, taking into account coherent hypotheses of the future evolution of world population growth, energy demand, efficient use, global economic growth among other considerations.

Step 4: Assessment of the level of adjustment of thermal building regulations to the new conditions imposed by the climate change

This final step includes a comparison between on the one hand, recent observed trends in climate and the envisaged climate conditions and on the other hand, weather patterns included in thermal building regulations.

CASE STUDY: ASSESSING THE LEVEL OF SPANISH BUILDING REGULATIONS ADJUSTMENT TO THE FUTURE CLIMATIC VARIABLES

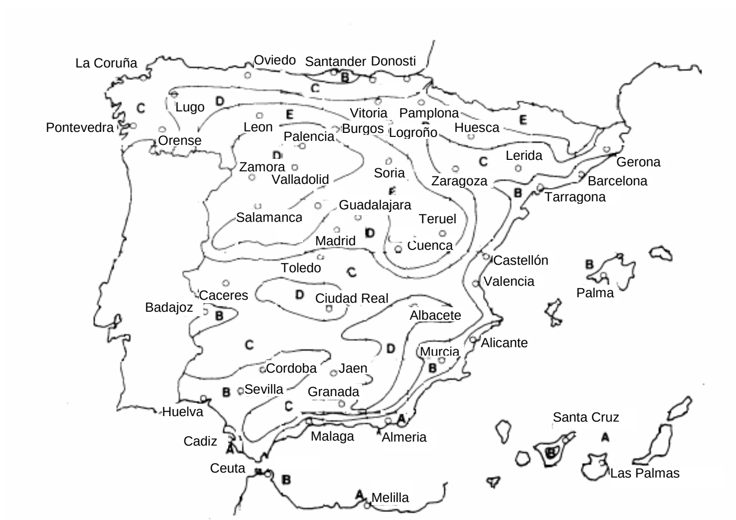
Step 1: Analysis of temperature influence into thermal building regulations.

This case study will be focused in NBE-CT 79 Thermal Conditions in Buildings approved by Royal Decree 2429/1979 of 6 July. This Compulsory Basic Building Norm defines the thermal conditions that buildings' envelope must satisfy in Spain, establishing two classifications based on climate factors. The first classification of the NBE-CT 79 divides Spain into five areas (from A to E), according to its annual degrees day. The second one establishes five areas (from V to Z), according to its mean minimum temperature in January.

Fig. 1 Climatic zones established in NBE-CT-79, according to its annual degree days.

Area	Annual degrees day based at 15ºC
A	≤ 400
B	401÷ 800
C	801 ÷ 1300
D	1300 ÷ 1800
E	> 1800

Fig. 2 Climatic zones established in NBE-CT-79, according to its mean Tmin in January.



Area	Min. temperature in January (ºC)
V	10
W	5
X	3
Y	0
Z	-2

Step 2: Analysis of recent observed trends in temperature during the 20th Century.

There is no doubt about the generalised temperature rise during the last quarter of a century [Moreno, (2005)]. According to *Hulme, 1999* during the 20th Century, annual mean temperatures in Spain showed a warming of 1.6ºC. Figures 3 and 4 show the warming underwent in Spain from 1901 to 2000 in degree days and the evolution of recorded minimum mean temperature in January.

Step 3: Establishment of climate change scenarios over the next 50 years in order to assess the likely changes in temperature values in a national scale.

Considering six global climatic models (CGM, CSIRO, HadCM3, NIES2, ECHAM4 and GFDL) included in DDC-IPPC database, Moreno, 2005 suggests that in Spain the temperature may increase from 2.1ºC to 3.5ºC during 2040-2070 period. The lowest warming is shown under the B2 Emission Scenario Family during the winter. For the A2 Emission Scenario Family the warming will be maximum (3.5ºC during the summer in the 2040-2070 period). In general, warming will be slightly greater in the summer season (June, July and August) than in winter.

Fig. 3 Degree days based at 15ºC in Spain from 1901 to 2000. Source: Own elaboration with information from Tyndall Centre for Climate Change Research.

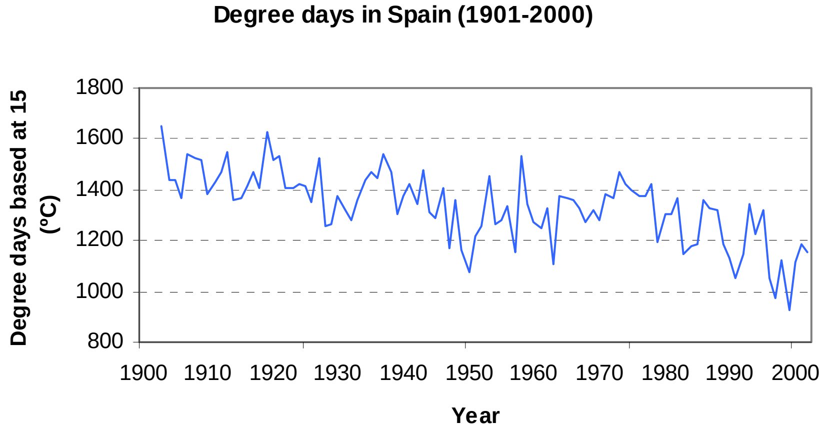


Fig. 4 Minimum mean temperature in January in Spain from 1901 to 2000. Source: Own elaboration with information from Tyndall Centre for Climate Change Research

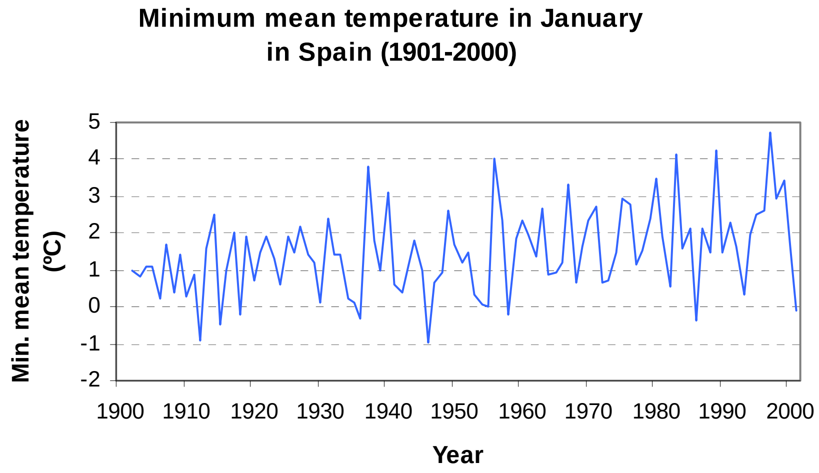


Table 1: Changes projected in surface mean temperature in the centre of Spain for the 2040-207 period in relation to the 1960-1990 period. Source: Moreno, 2005.

Season	SRES-A2 ΔT (ºC)	SRES-B2 ΔT (ºC)
DEF	2.3	2.1
MAM	2.6	2.4
JJA	3.5	3.2
SON	2.9	2.6

Table 1 shows the changes projected by the six global climatic models in surface mean air temperature (ºC) in the grid of each one, which includes the centre of the Peninsula. The results are seasonal averages (DJF winter, MAM spring, JJA summer and SON autumn) and correspond to two emission scenarios (A2 and B2). Changes are projected for the period 2040-2070.

As there is no available information about the changes projected in monthly mean temperature we have to accept that seasonal mean temperature can represent monthly mean temperature. Degrees day based at 15ºC calculated taking into account the above projections are 664 in the A2 scenario and 683 in the B2 scenario.

Step 4: Assessment of the level of adjustment of thermal building regulations to the new conditions imposed by the climate change

Analysis of the classification based on degree days

As stated above, Basic Building Norm NBE-CT-79 Thermal Conditions in Buildings divides Spain into five areas (from A to E) according to its annual degrees day (see fig. 1)

Analysing this classification with monthly mean temperatures from National Meteorological Institute recorded during the 1971-2000 period [Instituto Nacional de Meteorología (2001)], we can conclude that the 24% of the seventy nine Spanish weather stations studied should be classified in a warmer category whereas only two of them should be classified in a cooler category.

Degrees day based at 15ºC calculated taking into account climate projections are 664 in the A2 scenario and 683 in the B2 scenario, which corresponds in both cases to Area B in NBE-CT-79 classification. Considering that these projections concern to the centre of the Iberian Peninsula, weather stations such as Madrid, Guadalajara (initially considered in area D) or Toledo (initially considered in area C) should be classified in the next future in a warmer category.

Table 2: Spanish areas revised according dates from National Meteorological Institute.

Weather station	**Degrees day based at 15ºC**	**Classification in NBE CT 79**	**Actual classification**
Bilbao-Aeropuerto De Sondica	527.0	C	B
A Coruña	621.8	C	B
Pontevedra-Mourente	658.1	C	B
Madrid-Base Aérea de Torrejón de Ardoz	1226.3	D	C
Madrid-Retiro	1108.4	D	C
Madrid-Aeródromo de Cuatro Vientos	1177.8	D	C
Madrid-Base Aérea de Getafe	1165.7	D	C
Ciudad Real-Escuela de Magisterio	1141.7	D	C
Huelva-Ronda Este	262.8	B	A
Córdoba-Aeropuerto	543.9	B	A
Sevilla-Aeropuerto	329.3	B	A
Sevilla-Tablada	299.3	B	A
Cuenca	1590.1	E	D
Teruel	1721.1	E	D
Valencia	293.4	B	A
Palma-Centro Meteorológico	298.2	B	A
Ibiza-Aeropuerto San José	292.3	B	A

Analysis of the classification based on mean minimum temperatures in January

Basic Building Norm NBE-CT 79 Thermal Conditions in Buildings establishes five areas (from V to Z), according to its mean minimum temperature in January. (see fig. 2).

Comparing this classification with mean minimum temperatures in January from National Meteorological Institute recorded during the 1971-2000 period [Instituto Nacional de Meteorología (2001)], we can conclude the 19% of the seventy nine Spanish weather stations studied should be classified in a warmer category.

Table 3: Spanish areas revised according dates from National Meteorological Institute.

Weather station	**Mean $T_{minimum\ Jan}$ (°C)**	**Classification in NBE CT 79**	**Real classification**
Asturias-Aeropuerto Ranón	5.4	X	W
Asturias-Oviedo-El Cristo	4.2	X	W
A Coruña	7.6	W	V
Ponferrada	1.0	Z	Y
Segovia-Observatorio	0.3	Z	Y
León-Virgen del Camino	-0.8	Z	Y
Salamanca-Matacán	-0.7	Z	Y
Madrid-Retiro	2.6	Y	X
Melilla	9.9	W	V
Tarifa	11.4	W	V
Almería-Aeropuerto	8.2	W	V
Cuenca	-0.8	Z	Y
Albacete 'Los Llanos Base Aérea'	-0.4	Z	Y
Palma 'Centro Meteorológico'	8.3	W	V
Ibiza 'Aeropuerto San José'	8.1	W	V

Assuming that the change projected in temperature for the winter season can represent the increase in minimum temperature in January and considering that these projections concern to the centre of the Iberian Peninsula, weather stations such as Segovia, Leon and Salamanca (initially considered in area Z) or Ciudad Real (initially considered in area Y) should be classified in the next future in a warmer category.

CONCLUSIONS

The application of the methodology exposed in this paper has demonstrated that the Spanish Basic Building Norm NBE-CT 79 Thermal Conditions in Buildings must be updated taking into account the historical weather records from the last thirty years. Moreover, the current scientific consensus states that the growing tendency of mean temperatures will accelerate under the combined effects of historical and future emissions. Spain climate change scenarios for the 21st century agreed on a warming from 1.1 to 1.2ºC every 30 years in winter and from 1.8ºC to 2ºC in summer depending on the global climate model and the emission scenario family considered [Moreno, (2005)]. In this area, a major problem is the inevitable uncertainty in future climate predictions: although climate modelling will improve with time, the uncertainty that arises from future policy decisions on mitigation will not be reduced during the next years. At the purely conceptual level, taking this uncertainty about future climate into account should not be difficult. As building regulations at present are based on statistical analysis of data, climate change will add an extra element of uncertainty to this process but not introduce a new principle

Although thermal building regulations can be updated taking into account the new climatic context, the flux of new construction will be small when compared with stock of existing buildings, due to its long lifetime. Therefore, one of the most important questions still to tackle in Spain is the potential adaptation of the existing built environment to these weather changes.

It is necessary to emphasize that NBE-CT 79 only deals with winter situations. As recent observed trends in climate and Spain climate change scenarios for the 21st century agreed on a remarkable warming, it is foreseeable that the energy needs for heating in winter could conceivably decrease whereas the energy required for cooling in summer is likely to rise. Since the use of air-conditioning will significantly increase energy consumption and greenhouse gas emissions from buildings, it is urgent to include hot situations in the scope of thermal regulations. In addition, Basic Building Norm NBE-CT 79 supposes that the unique form to save energy is to use insulations. In order to save energy and to prevent climate change impacts, this norm should include solar earnings, contributing to the development of passive thermal control in buildings.

On 6 May, 2000, Act 38/1999, of 5 November, the Building Act (Ley de Ordenación de la Edificación, LOE) was enacted in Spain. The LOE establishes a set of basic requirements (mainly those relating to functionality, safety and habitability) which must be satisfied in order to guarantee the safety of people, the welfare of society, and the protection of the environment. In its Second Final Provision, the LOE authorises the government to approve a Technical Building Code (TBC) setting the mandatory standards required to ensure safety and habitability. Bearing in mind the importance of the climate change impacts on the built environment, Technical Building Code should include measures related to the adaptation to these changes of the building sector.

IMPACT

The exposed methodology, which constitutes the first step into the way of adoption of adaptation strategies to climate change in the building sector, can be easily applied to other countries in order to analyse other national building regulations. This methodology could also represent the basis for the development of further research in this field. Moreover, it could be the start point for future government initiatives addressing climate change adaptation, especially in case of revision of building regulations.

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Design for Production of Low Income House Building Projects

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Abstract
This paper presents an analysis of the integration of design and production processes for low income house building projects. It is based on a case study developed in a set of standardized designs from a Brazilian state house building company, which is responsible for the whole house building provision process, including design, financial, production, and demand management.
The research method comprised a literature review, followed by a comprehensive analysis of problems concerning design and production integration based on about 30 standardized residential designs, for low income citizens (40 square meters). This preliminary analysis identified a set of production restrictions and failure whose origins were in the design process, in spite of the repetitive production of these standardized designs. Finally, these design problems were examined based on a literature review on Design for Manufacture (DFM), in order to discuss the applicability of an adaptation of the DFM concepts to the building process, considering the particular features of the construction industry.
The expected impact of this study is to reduce the identified restrictions, and improve production and design integration in social house building projects.

Keywords
Constructability , design, design for manufacture, low-income house building .

INTRODUCTION

In Brazil, the provision of houses for low income families is regulated by governmental programmes, which are supported by funds operated by a public bank called *Caixa Economica Federal*. Such programmes focus especially on families who earn up to five minimum wages per month (US$640).

Besides *Caixa Economica Federal*, the execution of the governmental housing policies for low income citizens involves regional and local agencies known as house building companies, which are responsible for the identification of the demand, design, production bids or development, product delivery and post-occupancy evaluation. The Paraná House Building Company (*Companhia de Habitação do Paraná*, COHAPAR) is Paraná's state agency for the development of low-income house building projects in the cities with no equivalent structure. It manages the whole product development process (PDP): demand identification, design process, planning, supply, production, delivery and post-occupancy evaluation.

In COHAPAR's structure only production teams are decentralized. All the others functions are centralized in the company's headquarter, in the capital of Paraná state, Curitiba. These teams supply regional offices with architectural e complementary designs, budget, production time-line and material delivery schedule (as material acquisition is also made by the headquarters). In different regions, the company has production teams, which are composed by civil engineers (production managers) and foremen, which are responsible for workers recruitment or services hiring. In spite of a well-organized technical documentation for each project, there are no standard procedures for the production management.

On the other hand, one of the most relevant guidelines of Paraná *s*tate housing policy is to avoid standard patterns of low-income house building projects. This philosophy has lead the architects to develop a set of different layouts with different roof shapes, in order to fulfill the clients' basic needs of not living in a settlement for the poor citizens. At the starting point of the production of this new set of designs, many problems concerning constructability were issued. It was an opportunity to study the application of some concepts from the manufacturing design to the construction process especially those related to the integration of the design, and production processes, in order to improve product quality and production efficiency of low income house building projects. Among the favorable characteristics of this kind of project are the high level of repetition of the habitation units, the use of standard models, the fact that design processes, purchasing and production are subordinated to one organization, and the experience of the production management team.

INTEGRATION OF DESIGN AND PRODUCTION PROCESSES

The need for integration between design and production to improve quality and productivity is already recognized according to Fox et al (2001), both in manufacturing industry and in the construction industry. Although, according to these authors, while in manufacture such recognition has already resulted in widely announced significant advances, in the construction industry, low quality and productivity problems still persist. According to Fox et al (2001), the difference between these two contexts is the fact that in manufacture there has been development and application of methodologies which has lead to the improvement of the design process. Those methods comprised production requirements, trying to anticipate problems, which had not adequately been treated before, in the design stage.

In construction industry, Fox et al (2001) and Scott (1997) alert to the fact that, in addition to the lack of use of frameworks and methods, which systematically integrate design and production, there is a significant deficiency in the designer's knowledge and experience in construction techniques. According to Scott (1997) these features are due to the existing separation between the designers and the production practice, a feature in the construction industry.

The objective of getting production knowledge closer to the design stage, according to Jergeas and Van der Put (2001), could be called constructability, a concept meaning the incorporation of construction knowledge and experience in any product development stages: design, planning, supply or production.

McGeorge and Palmer[2] (1997, apud FOX et al, 2001, pg.494) argue that the procedures associated to constructability concept adopted in design for manufacturing in construction are characterized by informality and intuitive application. Besides, they alert to the fact that the introduction of some construction innovations (materials and components), through design specifications, have not been followed by an improvement of manpower qualification to the application of these materials and components.

The concept of constructability is also being used through a design method developed for manufacturing, and it is called Design for Manufacturing (DFM). According to Ulrich and Eppinger (2000), DFM aims to ensure high quality of the product at a minimum production cost. Manufacture experts have noticed that the designers' lack of knowledge of production capacity, as well as the lack of guidelines for costs and production constraints, could result in expensive components. In some cases, processes constraints could be simply communicated to designers in the form of design rules.
The teams usually involved in DFM include experts, from production engineers, accountants and production labors to product designers (ULRICH and EPPINGER, 2000). The DFM is pointed out as one of the most integrative practices to product development, being an essential part of PDP in many companies (ULRICH and EPPINGER, 2000).

One of the associate tools for the integration of the different stages in the product development process is prototyping. Ulrich and Eppinger (2000) indicate the use of prototypes to fulfill four distinct proposals: learning, communicating, integrating and establishing a milestone in the production process. According to those authors, the prototype can be a learning tool, once it provides an evaluation of the product operation and the extent to which this product meets the clients' requirements. The function of a prototype as a communication tool is easily noticed: graphic representation is not easily understood by non-technicians, even for people connected to the company, such as the marketing sector. Physical prototypes provide more effective communication.

Ulrich and Eppinger (2000) also emphasize that prototyping is an important tool to ensure that components and product subsystems work together as designed. Prototypes are the most effective integration tools in product development designs because they require physical interconnection of all product components. Therefore, prototyping implies coordination of different members in a diversity of disciplines of a product development team. If any component interferes in the product global operation and use, the problem could only be detected by a prototyping physical integration. Finally, a prototype could provide a functional evaluation of the product, mainly in advanced stages of product development, contributing to the establishment of a milestone in the production process.

RESEARCH METHOD

Based on the concepts analyzed in the literature review, a case study was developed to observe and understand the PDP in the construction context, specifically related to low-income house building projects (LIHBP).

The case study was developed in LIHBP undertaken by COHAPAR. A set of 32 standard house designs with 40sqm were analyzed, comprising living room, kitchen, bathroom and two bedrooms, built in reinforced concrete structure molded in loco, masonry of ceramic blocks and wood roof with ceramic tiles. It is a very simple and well-known pattern of construction in Brazil.

The data collection started with visits to one of the building sites, in order to characterize COHAPAR's production process. Then, the production manager of that site was interviewed to collect information about the problems related to interfaced design-production, later the researchers and the construction manager developed a comprehensive analysis of the design documentation. According to Scott (1997), the written instructions in a design can be seen as a summary of the design failures, and a lot could be learned from a careful study of these instructions. Therefore, the objectives of the design analysis were: (1) Identify problems and failures (difficulties for production and need for alteration); (2) Identify how those problems were detected by the production manager; (3) Describe how those problems were analyzed; (4) Analyze the solution adopted and (5) Analyze the results achieved.

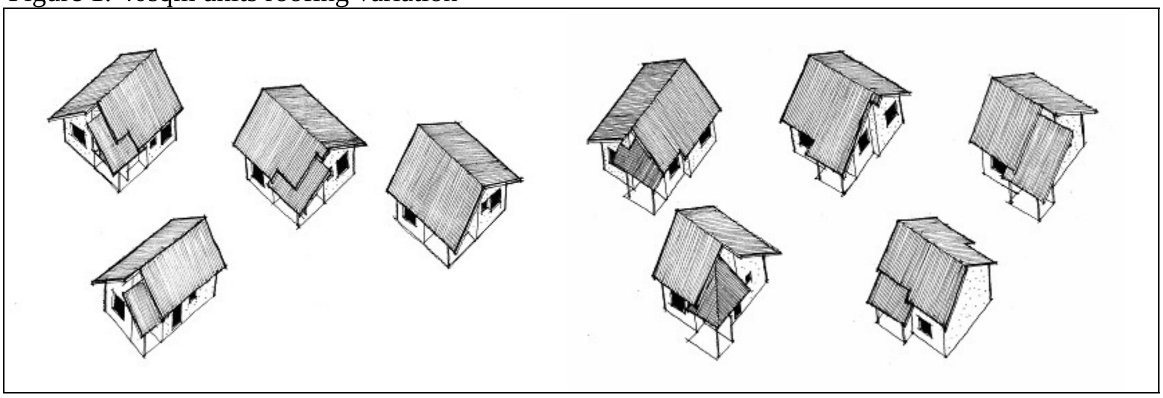
In a second stage, the survey of the problems was submitted to an architecture designer and a design researcher analysis, in order to get the point of view of the design stage, from independent designers, to identify the nature of those problems.

CASE STUDY

A careful examination of the 32 standard house designs resulted in the identification of 37 problems concerning lack of construction techniques knowledge by designers, drawing deficiencies, and failures in the concept of some components. More than 60% of those problems were related to roofing. So, in spite of also identifying important problems and alterations in other subsystems, this paper focuses on the design-production integration analysis in the difficulties found by the production team in assembling the roofing structure.

Since the first contacts with the COHAPAR designers, the study indicated diversity as one of the most important drivers for their design process. This is justifiable, because one of the critics to LIHBP of the last decades is related to the monotony created by the replication of standard units. Diversity, thus, has become a fundamental requirement for the design team. The attempt to provide an identity to each house, making the product more attractive to final clients, brought the unavoidable consequence of offering diverse unit options. Therefore, the design team decided to produce roofing variations and, mainly offering different kinds of balconies, as shown in Figure 1.

Figure 1: 40sqm units roofing variation



That strategy produced different effects along the design and production phases. The design of the roof became the major production constraint, creating a paradox: the attempt to explore the diversity of roofing models lead to such complexity that hampered production.

Identification of production problems

In spite of being a priority for the conceptual stage of the design process, the roofing presented serious failures both in the geometry concept and structure dimensions of its components. According to the production manager, most of the problems were related to bad specification of fixing elements to masonry, underestimated sustaining structure for the roof, and insufficient height under the lower part of the balcony.

Due to poor design data, the production management team found it difficult to understand the roof structure design. Hence, he proposed to build physical prototypes of each of the nine variations of structures in order to verify difficulties likely to be faced by the foreman and carpenters at the project site. The **prototyping** in fact evidenced many design problems. It was conducted by the production manager and the foreman, and monitored by one representative of the design team. Every problem was documented and discussed by this team. They also discussed and proposed design alternatives that were implemented in the prototype, and also registered. The design improvements were sent to the design team who were responsible for the final decision related to the alterations, and finally foward to other regional bureaus. The design team accepted most of the improvements proposed by the production team, based on the reasons presented, which included cost and production flow analysis.

The prototyping showed lack of integration between design and production stages. The problems identified through prototypes can be arranged in three categories:

1. <u>Design mistakes or lack of technical knowledge on building components features</u>: balcony under-reinforced structure, missing sustaining components in roof structural system and components with lack of reinforcement;

2. <u>Lack of experience or lack of knowledge of construction techniques:</u> geometric solutions and joints that were difficult to accomplish, incorrect rafter spacing, wood parts sustained directly by masonry, areas to be plastered that were difficult to access;

3. <u>Graphic representation or deficient/incorrect information:</u> deficient representation and identification of *fascias*, incompatibility between wood structure design dimensions and structural designs (reinforced concrete), missing representation of roofing parts,

One of the most important issues from prototyping was a formal arrangement with a wood supplier, in which all the roof components should be delivered to the building site, already cut and coded like kits for each house. Therefore, the carpenters in site would only have to assemble the components. This resolution aimed to establish standardized components, in order to reduce material waste and improve productivity. Nevertheless, according to the production manager, there are too many models for roofing and, despite the kits, the roofing services hamper production flow.

All the same, prototyping pointed out some problems and difficulties that would only be identified **during the production** of the units. However, most of the problems could have been easily anticipated and solved if production constraints had been considered during the conceptual stage.

DISCUSSION

The study of the roofing structure showed that, in spite of the product being quite simple and the design team having focused especially on the roofing in that set of standard design, the product development process (PDP) failed.

The COHAPAR's production team that joined the research group in this case study managed to take initiatives in order to improve constructability in those designs. However, the production team was not involved in the PDP process until too late. This fact resulted in a series of re-works for the design team. The company could take advantage of its major feature – the control over all product development stages – to integrate design and production. If so, the difficulties could have been anticipated at conceptual stage. The interface experience between design and production functions observed in the study conjures up practices from the Design for Manufacture method.

The DFM starts at the conceptual development stage, when product functions and specifications are determined (ULRICH and EPPINGER, 2000). An overall analysis of the product is undertaken: first, to identify and eliminate unnecessary components; secondly, to avoid conception of components that are individually easy to produce but collectively hard to assemble, in order to achieve simplification of the whole product design (McCabe, 1998[1] apud FOX et al, 2001, pg.497). The DFM method starts with a production cost appraisal of the proposed design. This helps to determine which design aspects – components, assembly, or support – are more costly. This is a cyclic process, in which it is not uncommon to review the production cost appraisal and improve the design a dozen times before agreeing it is good enough. At some point, the design is frozen and any extra modification represents formal "engineering changes" or becomes part of product new generation (ULRICH and EPPINGER, 2000).

This kind of approach provides an evaluation of production lead time during the design concept, in which over 80% of product quality and costs can be controlled (MILES e SWIFT, 1998[2] apud FOX et al, 2001, pg. 496). On the other hand, it demands multidisciplinary teams. In the construction industry it is almost impossible to have a staff in which designers, suppliers, sub-contractors and consultants work together during the early stages of the design processes (FOX et al, 2001). Even though, the development and management of standard-information are still uncommon into the Brazilian construction industry, because knowledge on production in this context tends to be sustained by the experience of practitioners, and there is no guarantee that the same practitioners, who keep that information, will be working together again. (FOX, et al, 2001).

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[1] McCABE, W.J. (1988). Maximizing design efficiencies for a coordinate measuring machine. DFMA Insight, **1** (1), Boothroyd Dewhurst,.

[2] MILES, B.L. e SWIFT, K. (1998) Design for manufacture and assembly. Manufacturing Engineer, 77 (5), 221. .

However, COHAPAR has a system that centralizes and control every stages and agents of PDP, they lack management capabilities in order to improve effectiveness of their own process. This means that the concentration of all processes by one enterprise makes it easier to register and standardize production information, and benefit future designs development. Therefore, the knowledge remains in the company, always providing an evolution related to early designs. For example, in the case study the difficulties identified in the building site or in prototypes could have been avoided if during the design concept stage, the production team had provided the design team some of the constraints concerning material and building techniques.

The analysis of the roofing in this case study showed that the use of the DFM method could improve the quality of designs in the company and also reduce production costs. The production team realized that the anchoring system of the balcony's wood beam presented in the design was not adequate: it was both structurally insufficient and complex to build. Soon the production team solved the problem changing the whole beam anchoring system by another simpler and more resistant one. This change resulted in cost and time reduction to the building process. It was communicated to the design team who analyzed and accepted the design modifications, and incorporated into the design of future projects. In DFM practices, it is possible to see components being re-designed to eliminate process steps. A careful examination of the proposed design can bring suggestions that could result in simplification of the production process. The reduction in the number of steps in manufacturing a part usually leads to cost reduction. Some steps could simply be unnecessary. In some cases various steps could be eliminated through the substitution of an alternative process step. (ULRICH and EPPINGER, 2000).

The minimization of Systemic Complexity is also an important DFM guideline. The complexity is originated from the variety of inputs, production (outputs) and transformation process. Many real fabrication systems involve hundreds of suppliers, and dozens of product process types. Each variable should be usually traced, monitored, managed, inspected, worked and inventoried causing high costs to the enterprise. Most of this complexity is driven by the product design and can be minimized through intelligent design decisions (ULRICH and EPPINGER, 2000). This DFM driver is directly related to the difficulties detected in the company in study, about the roofing execution. The design team's proposal of nine models of roofing increased the PDP systemic complexity, because this larger number of roofing models created a larger number of prototypes too, more time spent to develop them and more people involved in this construction. This shows that the decisions made in the design stage, unaware of production constraints and without knowledge on production techniques, is generally detrimental to the whole process. On the other hand, the alternative created by the production manager, using roofing *kits*, decreased the production process systemic complexity. Because in doing this, the company reduces the roofing production time, the number of workers, and material waste.

FINAL COMMENTS

The objective of this paper was to present an analysis developed in a case study concerned with the design of low-income house building. Despite the simplicity of the house units and the centralization of the product development process, this study showed that there are many opportunities to improve quality and efficiency in the process.

Most of the problems identified in this study were related to the lack of integration between design and production processes. Although the production team is already implementing initiatives based on constructability, the analysis showed that there is a need for a systematic organization of PDP in COHAPAR practices, in order to get more effective results from those initiatives. The authors believe that, as well as in manufacturing, methods like DFM can lead to significant improvements in the quality of PDP in construction.

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Effect of Socio-Cultural factors on Housing Quality in Osogbo, Nigeria

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Abstract
This paper examined the effect of socio-cultural factors on the quality of housing in Osogbo, Nigeria. Four hundred and six 406 household heads selected from 200 subdivided quadrants were interviewed using already prepared questionnaires. The information collected from the field were subjected to one-way analysis of variance (ANOVA). The study established that with the exemption of ethnicity. All other socio-cultural variables (age, religion and marital status) have significant influence on housing quality at 0.05 probability level.

The need for planners to consider socio-cultural factors of the people when planning for new housing is highlighted.

Keywords
Housing, culture, social norms, habit, perception

INTRODUCTION

Shelter has always been one of man's basic needs. Man needs shelter for protection, comfort and security. Throughout history, man has tried to reshape his immediate environment so as to provide himself with a means of cover and protection from external elements. In order to meet these desires, the house needs to be constructed to satisfy certain standards of construction, space arrangement, hygiene and comfort. The house and building forms created by so doing becomes a physical expression of man's cultural and social system (Mills-Tettey, 1989). Rapoport (1969) opined that house form is not simply the result of the physical forces or any single casual factor but the consequence of a whole range of socio-cultural factors seen in their boldest terms. According to him, the specific characteristics of culture – the accepted ways of doing things, the socially unacceptable ways and implicit ideals – needs to be considered since they affect housing and settlement form. This includes the subtleties as well as the utilitarian features.

Cultural structures, therefore, are integrals of civilization manifested in a system of behaviours, activities, praxis and life-styles at the individual and collective levels of the society. In sociological term, every civilization produces its own housing forms, highly reflective of the historically prevalent cultural values and objectively conditioned by the structural system of social organization and production relations (Awotona, et al. 1994).

The socio-cultural values of every man is known to vary from one society or civilization to another and these values have both direct and indirect influences on man's habitation. For instance, in Nigeria, the predominant traditional house form is the compound house form, which varies in pattern with the different ethnic settings that made up the country – Yoruba, Ibo and Hausa (Mills – Tettey, 1989; Ojo 1966). These variations are the products of the socio-cultural factors and values peculiar to the different ethnic groups.

A man's position in the society, occupation and other resources also tend to affect the house he builds for himself (Mills-Tettey, 1989). This is because the house is seen as an important investment, (Godwin, 1997).

However, the present day man builds more than basic shelter for housing. The dictates of present day urban life, influence of colonialism and development of newer building materials have affected urban house types in developing nations especially Nigeria. Mills-Tettey, (1989) and Ojo (1966) gave reasons for this development as due to cultural contact with foreign civilization. These facts notwithstanding, the effect of socio-cultural values and lifestyles of the people are very much inherent in the determination of housing preference.

In this light, if the essence of a house is to be fully appreciated within the context of human habitation, then the need for the preservation and promotion of socio-cultural values through housing design and forms should not be predicated on emotional and overzealous rhetoric, but on the relationship between housing and cultural structures.

It is on this note that this paper attempts to identify the role of social and cultural factors in the determination and provision of the much-desired functional and qualitative housing in our urban environment by positing the case of Osogbo, Nigeria. In essence objective of the paper is to examine the housing quality and to determine the relationship between the housing quality and some socio-cultural factors in Osogbo, Nigeria.

THEORETICAL ISSUES

Four concepts shall be recognized and discussed in this paper. These are housing, culture, socio-cultural factors and housing quality.

The World Health organization (WHO) in 1961 described housing as the provision of any physical structures usually used for shelter. It includes all facilities, equipment, services and devices needed or described for healthful leaving.

Kick lighter et al (1986) stressed that the term housing refers to more than just a dwelling. It also includes all that is within the dwelling. It is the creation of a special environment in which people live and grow. And according to Godwin (1997), the house is perceived as 'the space that we can call our own, that gives us privacy that shelters us from the weather, and above all from the intrusion of unwanted people.

Etinger (1997) asserted that 'the life of man has its natural setting in what happens in, around and from his house. Housing is therefore connected with the essence of life. Having a roof over one's head is a human right'. In line with and support of these attributes of housing, Hayakawa (1983) opined that 'it is not too much to say that housing is of the greatest importance because it affects the whole of life in every way: that is health, security and culture. It is related to human life day-in and day-out and is the most important basis for development of the total human personality in society'.

The relevance of culture in the determination of housing form and design cannot be over emphasized. Several authors have defined culture in different ways in order to suit their research objectives. Gyuse (1989) defined it as 'the acquired or cultivated behaviour and the thoughts of the individual within society as well as the intellectual, artistic and social ideals which members of the society profess and to which they strive to conform'. This implies their worldview, principles of social organizations such as family structure and their social behaviour as reflected in the daily cycle of activities.

Arising from these definitions, Onibokun (1985) identified family patterns, tenure system and social status as relevant factors in social and cultural issues. Thus, every civilization produces its own housing forms, highly reflective of the historically prevalent cultural values and objectively conditioned by the structural system of social organization and production relation.

In essence, socio-cultural parameters are very important in the determination of suitable house form as clearly expressed in the statement of Rapoport (1969) that 'house form is not simply the result of the physical forces or any single casual factor but is the consequences of a whole range of socio-cultural factors seen in broadest terms – the specific characteristics of culture- the accepted way of doing things, the socially unacceptable ways and implicit ideals – needed to be considered since they affect housing and settlement form'.

Quality is a product of subjective judgment (Jones, 1979; Anantharajan, 1983; Olayiwola, 1997). It arises from the overall perception which individuals in the setting of interest holds towards what they see as the significant elements of the setting at a particular point in time. This to some degree is value judgment. Housing quality therefore results from the overall perception of residents. According to Abloh (1980), housing acceptability takes into account type of construction, materials used, amount of spaces, services and facilities. Other indices include ways of life, income levels, domestic habits, space arrangement, value and priorities, nearness to work place or town centre, adequate facilities within dwelling, privacy, design, function and aesthetics, noise, pollution, unfriendly neighbours and personal insecurity.

The works of Rapoport (1969, 1976) and Lawrence (1987) established that traditional values and house patterns among others are relevant determinants of quality in housing. And according to Gur (1994), house type, general physical properties of the house such as number of rooms/spaces, sewage system, house size, facilities within the house, alteration to the house, environmental problems, possible misplaced spaces among others are variables that can affect housing quality.

However, in most third world countries like Nigeria, housing studies using the input from human values are negligible. Yet they are relevant to how housing projects could be improved upon. It is for this reason, that the effect of socio-cultural attributes on housing quality in developing countries like Nigeria is being investigated.

The relevance of the study to the development process is the provision of policy response that will accommodate the utilization of human values in the determination of housing needs of the people in Nigeria and in the nations of the world in general.

A BRIEF BACKGROUND OF OSOGBO

Osogbo was founded in the late 17th century between 1650 and 1700 and became the capital of Osun State in 1991. As the state capital it has two local governments which are in Osogbo and Olournda local governments with their headquarters at Oja Oba and Igbonna respectively. Its population as at 1991 was put at 336,694 (Akanji, 1994). The total land area is about 2,875 sq. km before it became the state capital (Akanji, 1994). This indicates that the city has grown spatially by 192.3% after the state creation.

Osogbo is situated on latitude 7^{0} 7" North of the equator and longitude 4^{0}50" East of the Greenwich Meridian. The city has an annual rainfall of about 2 ft. (0.6m), lies mainly in the deciduous forest and is located on an elevated land of over 800 ft (244m) above sea level.

There is considerable variation in the physical pattern of the city. At the centre of the city are the Oba's palace and the traditional market called Oja Oba, surrounded by residential houses, which form the core of the city. Next to the core area is the intermediate zone (between the core and the new area). After the intermediate zone there is the newly developed area, which comprises modern structures.

RESEARCH METHODOLOGY

The data for this study were derived from primary source. The primary data were derived through questionnaire administration. The questionnaires were administered on 406 respondents selected from 137 quadrats in Osogbo Township.

The review of literature and personal reconnaissance survey showed that three zones of residential development are discernible in Osogbo Township. These are the inner traditional core area (zone A); the intermediate zone between the inner traditional core and the periphery (zone B); and the newer residential districts and periphery (zone c). The three identified zones were further subdivided into quadrats based on the grid lines already existing on the map. Samples were then selected from quadrats using the principle of stratified systematic unaligned dumpling technique advocated by Bevvy and Baker (1968) see table 1: for the quadrats and the number of questionnaire administered in each identified category.

Table 1: Distribution of sample Stratum

Zones	*No of Quadrats*	*No of Samples per Quadrats*	*No of empty cells*	***Total sample per zone***
i	ii	iii	iv	v
A	12	8	-	96
B	15	6	-	90
C	173	2	63	220
Total	200	16	63	406

Source: Field Survey, 2005.

The respondents to the questionnaire administered were the household heads. The sampling frame was the house in the selected quadrats. One household head per house was engaged in interview and questionnaire administration.

The questionnaire administered was designed to collect data on the socio-cultural characteristics of the people (age, income levels, and Domestic habits) marital status, religion as well as the type and pattern of housing being occupied, the facilities available within and around such dwellings and the general housing environment. The data collected were analyzed using statistical analysis such as frequency table and one-way analysis of variance (ANOVA)

Analysis of Data

The sample demonstrates the socio-cultural features of the households, which have significant influence on their perception of housing quality in Osogbo Nigeria.

Table 2: Socio-cultural characteristics of sampled households

SOCIO-CULTURAL CHARACTERISTICS	***NUMBER***	***PERCENTAGE***
SEX		
Male	238	58.6
Female	168	41.4
Total	406	100.0
AGE		
Below 20 years	17	4.2
21 – 30years	38	9.4
31 – 40	188	46.3
41 – 50	138	34.0
51 – 60	23	5.7
Above 60years	2	0.5
Total	406	100.0
MARITAL STATUS		
Single	46	11.3
Married	336	82.8
Divorced	14	3.4
Widowed	4	1.0
Separated	6	1.5
Total	406	100.0
RELIGION		
Christianity	206	50.7
Islam	199	49.0
Traditional	1	0.2
Total	406	100.0

OCCUPATION		
Student	33	8.1
Self-employed	168	41.4
Civil service	174	42.9
Farming	1	0.2
Others	30	7.4
Total	406	100.0

EDUCATION		
Primary	46	11.3
Post-primary	198	48.8
Tertiary	112	27.6
Vocational	43	10.6
Others	43	10.6
Total	406	100.0

ETHNICITY		
Yoruba	396	97.5
Igbo	8	2.0
Hausa	2	0.5
Total	406	100.0
INCOME		
Below 5000	67	16.5
5001 – 10000	116	28.6
10001 – 15000	114	28.1
15001 – 20000	97	23.9
Above 20, 000	12	3.0
Total	406	100.0

Source: Field Survey, 2005.

There are more male household heads than females as 58.6% of the people contacted are males. This explains the extent to which men traditionally dominate the households. It is evident from table 2 that more than 80% of the samples are 31years of age or more, while barely less than 5% are less than 20 years old. This suggests that most young adults still live within the household of their parents. Majority of the selected samples are married household heads, as 82.8% of the samples claimed they are married. The incident of divorce/separation is minimal among the respondents.

Data collected as shown in table 2 reveals that most of the respondents belong to the Yoruba ethnic group. This group represents 97.5% while other respondents belong to Igbo (2.0%) and Hausa (0.50%) ethnic groups.

A large percentage (60.1%) of the household respondents (as indicated in table 2) contacted have just primary or post primary education as the case may be. Just about 27.6% of the respondents have post secondary education. Barely 21.2% have vocational on other unclassified type of education.

Based on the appropriate portion of tables 2 the basic occupation engaged in by the households in the study area are farming, civil service, schooling, artisan and such others as trading and minielectrical works. From the table, it is evident that majority of the respondents are civil servant. Self employed respondents' ranks second among the occupation.

Information on the income of household heads are very difficult to collect. First because they are not well educated. Secondly because most of the respondents who are farmers and traders do not keep records of their sales. Thirdly, they are not on fixed and regular income. In any case more than 50% of the household heads contacted were able to give an estimate of their annual income. The outcome of this is as shown in table 2. In the table it is revealed that 16.5% of the household heads earn less than N5000 a year and 83.5% earn more than that amount. It is possible that the religion, occupation and other related socio-cultural factors could have some influence on the perception of quality of housing in the study area.

PERCEPTION OF QUALITY OF HOUSING

This section explores the various elements which could be added up to arrive at the perceived housing quality in the study area. The discussion is based on the following sub-heading: Sources of water supply, electricity, waste disposal, drainage, road network, Building design, and building infrastructures.

SOURCES OF WATER SUPPLY

As may be expected most houses in Osogbo are connected to the source of water supply which is generated from the main scheme at Ede. Osogbo has a major booster station and office which oversees the supply of water to areas within and around the town. Only 310 houses representing 70.4% of the houses sampled were connected with the main water supply. (as shown in table 3). Eighty –eight (88) houses representing 21.7% of the houses sampled depend on well water, while 1.9% got water from other sources such as vendors, streams among others. Residents connected to water source in Osogbo confirmed that regular water supply is being enjoyed by them. This may be due to the closeness of Ede water scheme to Osogbo, which incidentally has Nigeria Power Holding Booster Station supplying electricity to Ede in return.

Table 3: Sources of water supply, electricity, method of waste disposal and drainage system

ELEMENT OF HOUSING QUALITY	*NUMBER*	*PERCENTAGE*
SOURCES OF WATER SUPPLY		
Vendors	3	0.7
Well	88	21.7
Pipe-borne	310	76.4
Bore-hole	0	0
Others	5	1.2
Total	406	100.0
DISTRIBUTION OF ELECTRICITY		
Not available	2	0.5
Disconnected	6	1.5
Available	398	98.0
Total	406	100.0
METHOD OF WASTE DISPOSAL		
Dung pit	170	41.9
Burning	32	7.9
Refuse bin	192	47.3
Local Govt. collection	12	3.0
Total	406	100.0

PERCEPTION OF DRAINAGE SYSTEM		
Very bad	34	8.3
Bad	60	14.8
Fairly good	252	62.1
Good	41	10.1
Very good	19	4.7
Total	406	100.0

Source: Author's field survey, 2005

SOURCE OF ELECTRICITY

Where there is potable water, electricity supply may not be too far away. In this study, 98.0% of the houses sampled are connected with electricity supply from the national grid. Just 1.5% and 0.5% of the houses sampled have electricity supply disconnected or not connected at all as the case may be.

METHOD OF WASTE DISPOSAL

The result of survey suggests that some parts of the study area-Osogbo experience poor sanitation. According to the survey, residents of about 192 houses (47.3%) claimed they dispose their waste into refuse bins. Some dispose theirs on dung pits (94.1%). Quite a few dispose their refuse by direct burning. This represents 7.9% (32) houses, while very few residents enjoy local government refuse collection services. This represents 3.0% (12) houses. (see table 3)

DRAINAGE SYSTEM

Based on the data on table 3, the residents of the study area perceived the drainage system in Osogbo as just fair. This represents 62.19% (252) respondents, while 10.1% and 4.7% perceived it as good or very good as the case may be. Only 8.3%t and 14.8% of the respondents perceived their drainage as very bad or bad respectively.

The improved state of the system in Osogbo may be as a result of the town's status as the administrative capital of Osun State. It has a state environmental protection Agency and Capital Development Authority overseeing the cleaning and sanitary conditions of the town.

BUILDING DESIGN

A cursory visit to the study area shows that the popular housing type is the Brazillian (face-me-face-you) house type. It is clear from table 4 that most of the household respondents (98.5%) claimed that their building design is good, fairly good (70.4%), Good; (25.4%) and very good (2.7%). Just 1.0% and 0.5% of the respondents' claimed the building design is very bad or bad as the case may be.

Table 4: Perception of Building Design

PERCEPTION	*NUMBER*	*PERCENTAGE*

BUILDING DESIGN		
Very bad	4	1.0
Bad	2	0.5
Fairly good	286	70.4
Good	103	25.4
Very good	11	2.7
Total	406	100.0

Source: Author's field of survey, 2005.

The data showing that the greater percentage of respondents perceived the building design as fairly good only attest to the fact that people's preference for the contemporary Brazillian house type is being justified and ascertained. Respondents who perceived the building design as good or very good are those who probably have lost bearing with the Yoruba cultural heritage and values most of these people are found in the modern contemporary house types such as flats, duplexes and single family dwellings.

PERCEPTION OF INFRASTRUCTURES AND BUILDING ELEMENTS WITHIN THE HOUSING ENVIRONMENT

A review of available literature suggests certain infrastructural facilities and building elements represent quality indicators within the housing environment. The availability and conditions of the infrastructural facilities and building elements were used to assess the level of satisfaction of the household respondents.

The infrastructural facilities and building elements that were measured are as indicated in table 5.

Table 5

A. **Infrastructural Facilities**

1. Market/shop
2. Restaurant
3. Bank
4. Gneina
5. Post Office
6. Play ground
7. Health Centre/Clinic
8. Community Centre
9. Place of worship
10. School

B. **Building Elements**

1. Floors
2. Windows
3. Wall Finishing
4. Ceiling
5. Walls
6. Roofs
7. Ventilation
8. Lighting
9. Privacy

In measuring level of availability of infrastructural facilities within the housing environment, respondents were asked to indicate those infrastructures that were available within their housing area. The number of amenities indicated by each respondents was classified and assigned weight values using five-point rating scale as follows: very inadequate =0, inadequate =1-3; fairly adequate = 4-7; adequate =8-11; very adequate = 12 and above.

Similarly, in rating building elements, the respondents were asked to rate the (9) building elements based on assigned weight values. This weight values depend on the quality of the physical appearance, fitness and functional stability of the building.

A minimum value of zero (0) and a maximum of 36 were obtained. These values were classified using a five-point rating scale as follows: very
Bad =0; bad =1-9; fair = 10-18; Good =19-25; very Good = 28-36.

From table 6, 386 household respondents representing 95.1% rated the facilities within their housing environment as inadequate,, 18 respondents (4.4%) rated it as fairly adequate, while 2 respondents (0.4%) perceived it as adequate. In otherwords, infrastructural facilities are generally inadequate in the study area. This implies that most households in Osogbo do not have access to necessary infrastructures within their housing environment.

Table 6: Perception of Infrastructural Facilities and Building Elements

Element rated		*Number*	*Percentage*
INFRASTRUCTURAL FACILITIES			
Weight valve	**Facilities rating**		
0 – 2	Very inadequate	6	1.5
3 – 5	Inadequate	11	2.7
6 – 8	Fairly inadequate	280	69.0
9 – 11	Adequate	55	13.5
12 – 16	Very adequate	54	13.3
Total		406	100.0
BUILDING ELEMENTS			
Weight valve	**Facilities rating**		
0	Very bad	1	0.2
1 – 9	Bad	4	1.0
10 – 18	Fair	216	53.2
19 – 27	Good	163	40.2
28 – 36	Very good	22	5.4
Total		406	100.0

Source: Author's field survey, 2005.

With regards to the building elements, just 0.2% and 1.0% of the respondents perceived the building elements as very bad or just bad as the case may be. 216 respondents representing 53.2% perceived the element as fair. 163 respondents representing 40.2% perceived the elements as good, while 22 respondents or 5.4% of the total respondents perceived the elements as very good. The fact that a great percentage of the respondents perceived the quality of the building elements as fair, implies that the quality level of these elements is below the desire and expected standard.

INFLUENCE OF SOCIO-CULTURAL VARIABLES (AGE, RELIGION, ETHNICITY AND MARITAL STATUS) ON HOUSING QUALITY.

Analysis of variance was adopted to investigate the influence of socio-cultural factors such as age, religion, ethnicity and marital status on the overall housing quality in the study area. Table 7 shows the overall statistics obtained from the one-way analysis of variance between socio-cultural variables and housing quality.

Table 7: Influence of socio-cultural variables (age, religion, ethnicity and marital status) on housing quality

Socio-cultural variables	*Sum of Squares*		*Mean Square*		*df*		*f*	*p*
	1	2	1	2	1	2		
Age	1588	33058.60	317.72	84.14	5	400	3.77	0.002*
Religious	780.73	34466.49	390.37	85.53	2	403	4.56	0.01*
Ethnicity	227.19	35020.04	113.59	86.90	2	403	1.307	0.272

Marital Status	1410.32	33836.90	352.58	84.34	4	401	4.18	0.003*

**Significant at o.05 Source: Computer Output*

As could be seen from the table, the sum of squares between and within groups of the socio-cultural variables are higher than the mean squares. When the values obtained from this analysis were subjected to one-way analysis of variance (ANOVA). The F-ratio obtained are 3.77 for age variable, 4.56 for religion and 1.307 and 4.18 for ethnicity and marital status respectively. All these figures with the exemption of ethnicity were significant at 0.05 level of significance. Therefore it can be stated that socio-cultural variables such as age, religion, and marital status all have significant influence on housing quality in Osogbo.

CONCLUSION AND FUTURE AREA OF RESEARCH

This paper has attempted an examination of the effect of socio-cultural variables on housing quality in Osogbo. The findings show that the quality level of building and infrastructural elements such as waste disposal, drainage system, building space and design are below the desired and expected standard in the study area. The findings also show that with the exemption of ethnicity, other socio-cultural factors such as age, religion and marital status have significant influence on housing quality in Osogbo.

Since this study is man-centred. A study of the socio-cultural factors of housing quality may not necessary tell all the stories of perceived quality of housing. As the socio-economic characteristics of the people were not considered, in the study it may be necessary to investigate the effect of socio-economic characteristics on the perception of housing quality. This is desirable because variables such as earning capacity, stage in life cycle level of education and occupation can go a long way to further determine man's perception of housing quality.

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Analysis of the development process of social houses in Ceará state

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Abstract
As part of the research project entitled "a model of social housing for the state of Ceará", the present article intends to show the current situation of the process of development of the product (PDP) of social houses (SH) produced by the government of Ceará, the City Hall of Fortaleza and a non-governmental Organization (NGO) that is active in the state. This analysis will show the qualities and problems of the existing processes. First of all, we've studied the programs that supported the construction of these SH. After, we collected information about the projects of SH already developed by the institutions above cited, about the ones being currently implemented and those soon aimed at. We also tried to understand the development process of the housing typologies used by these institutions. We've chosen three case studies to understand the satisfaction of the users. At the same time, we've tried to understand the wishes of the families that still live under abnormal conditions regarding a housing tipology. Then, we've prepared questionnaires and based on that we will define the PDP and later the project process of typologies adequate to the reality of Ceará.

Keywords
Housing of social interest, development product, project process.

INTRODUCTION

This study is part of the research entitled "A model of housing of social interest for the state of Ceará" (HISCE) that was carried out by the Federal University of Ceará (UFC). The institutions that cooperated with it were Ceará State University (UECE), the Vale do Acaraú University (UVA), the Regional University of Cariri (URCA), the University of São Paulo (USP), the Center for Industrial Technology Foundation (NUTEC) and the Laboratory of Studies in Architecture and Urbanization of UFC (LEAU). Therefore, this is a national project, financed by FINEP (Agency for Financing of Studies and Projects) and CNPq (Brazilian Committee for Scientific and Technological Development).

The work' main objective is to analyze the development process a product, namely a housing of social interest, in the public institutions in the state of Ceará. To achieve that, it was necessary to know the housing problem in the state and the agents that deal with that area.

The fact that the housing of social interest is usually immediatist, always done very fast, causes its project, most of the times, not to take the user's needs into consideration. From the analysis of the development process of the product, we will get information that is decisive in the decision taking in the design process of those houses.

This article presents all that way: description of the housing problem in the state of Ceará, the agents' role in the housing issue and the analysis of the development process of the product (including methods used and results obtained). In the end, we present the conclusions.

THE PROBLEM

In the last decades, Brazil has gone through an intense process of urbanization that between the 50's and 80's decades, through a large migration of population from the rural area to the urban one, has changed it into a dominantly urban country.

In the second half of the 20th century such an urbanization process led to the formation of 12 metropolitan areas and 37 non-metropolitan agglomerations that together started to concentrate 47% of the country's population. Already in the 80's decade, those metropolises accounted for 30% of the country's demographic growth and, together with that growth, according to data of IBGE (Brazilian Institute for Geography and Statistics), increased the number of people living in slums (118.33%) as well as the number of dwellings situated in slums (133.19%) also increased.

In 2000, the rural exodus caused the rural population in Brazil to vary from 63.8% to 18.8% in 1950 (HOERNING apud IBGE, 2005). Nowadays there are 26 metropolitan areas that concentrate 34% of the Brazilian population and 84% of the urban population [Hoerning apud Maricato, 2005].

In Ceará State, the reality is not different. Mainly in the years 1970 and 1980, we can notice a strong rural exodus generating an exponential growth of the urban population and the consequent reduction in the rural population [Hoerning, 2005]. In Fortaleza, for instance, in the beginning of the fifties there were two 200,000 inhabitants while in 2000 its population was already 2 million inhabitants.

We have then a great movement of city construction to both supply the housing needs of that population and also meet the demands for work, transport, health, energy, water etc. [Maricato, 2002].

Such changes bring with them several problems related to the housing issue, such as cohabitation, precarious houses, self construction, lack of infrastructure and those problems, as a result, end up generating "disasters caused by erosion, floods, land slides, indiscriminate destruction of forests and protected areas; contamination of groundwater table and of water supply dams; epidemic diseases and diseases caused by humidity and lack of ventilation in the improvised homes, or by sewage and wastewaters that run in open air, among others" [Grostein, 2001].

Taking all those changes into account, in 2000 the housing deficit in Brazil was estimated in 6,656,526 new homes (81.5% of the total deficit in Brazil and being dominantly urban). The Northeastern region leads the national demand for housing, with an estimated demand for 2,631,790 home units. Next, comes the Southeastern region. Those two regions account for 78.8% of the Brazilian housing deficit.

The metropolitan areas account for 29.3% of the total demand, representing 1,952,677 units.
Analyzing the issue in relation to the percentage of total permanent private homes, the housing deficit stands out in the states of the Northeastern region, particularly in Maranhão, Rio Grande do Norte, Piauí and Ceará States, and in the urban areas of the Northern Area, especially in Pará, Roraima and Amapá. [João Pinheiro Foundation, 2002].

In the state of Ceará, the housing deficit is of 391,717 home units, what represents 22.29% of the total of permanent private homes. On the other hand, there are 301,564 unoccupied private homes in the state. The situation of the metropolitan region of Fortaleza (MRF) as well as of the towns considered as poles of development in the state is not very different. In the MRF the housing deficit is of 122,988 home units while 102,966 unities are unoccupied.

THE AGENTS

In the state of Ceará there are several institutions working, in some way, for the solution of the housing problem, namely: the state government, the City Halls, non-governmental organizations and several other organized groups of civil society.

The State goverment

The state government, through the Secretaria de Desenvolvimento Local e Regional – SDLR (Department of Local and Regional Development) deals with the housing issue in two aspects: one through the Project of Urban Development and Management of Water Resources (PROURB) and another by the Department of Housing which is the institution that replaced the former COHAB (Housing Company) in the state.

The PROURB prepared 46 Master Plans of Urban Development (MPUD's) and a Housing Master Plan for the state of Ceará (PDH), which was recently launched. The 46 MPUD's also included the housing issue and, for each town supported by PROURB, a housing development project was developed aiming to solve a serious housing problem in the place.
The State Department of Housing is at the moment developing about six housing projects that focus not only on the construction of housing units, but also on the implementation of urban infrastructure and the readjustment of previously degraded spaces. Those projects were financed by the following programs: Pró-Moradia (Housing Supporting Program), Habitar-BID (Habitation Program supported by the Inter-American Development Bank), and Habitar-Brasil (Habitation Program financed by the Brazilian government. The current projects are being carried out in Fortaleza, but other towns in Ceará State were also supported by the former COHAB through the construction of housing units.

The City Hall of Fortaleza

The City Hall of Fortaleza has already dealt with the city's housing problem through several departments. The previous administration addressed the problem through its regional executive sections, in other words, in a decentralized way. Also in the former administration there was already the Fundação para o Desenvolvimento Habitacional de Fortaleza – HABITAFOR (Foundation for Housing Development of Fortaleza), which, at that moment, was responsible only for the development of the HABITAR-BRAZIL-BID project in the Opaia Pond. However, in fact, there were many other departments of the City Hall that were responsible for housing problems, even the Mayor’s Cabinet, and none of those knew what the other institution was dealing with.

Therefore, the HABITAFOR Program is going through an internal restructuring process aiming to concentrate all of the municipal actions on the housing area. The projects under development are the housing developments at the Opaia Pond and Maravilha slum and other smaller projects in areas situated in land parcels that were given to the City Hall to be used for social interest purposes. HABITAFOR is also dealing with the revision of Fortaleza master plan, the land readjustment and people’s participation in all of those processes.

Other organizations

Social organization is of utmost importance when dealing with habitability issues.

The Catholic Church encourages civil society to organize itself through the church commissions and the base ecclesiastical communities (BEC’s), strengthening the popular movement. In the archdiocese of Fortaleza there are several organizations dealing with the housing issue: The urban land church commission, the street people church commission, the diocesan Caritas and the Center for Protection and Promotion of Human Rights (CDPDH). [HOERNING, 2005].

The need to discuss planning for Fortaleza, also because of the deterioration of the housing situation, caused the first popular housing movement to emerge – the Interbairros. With the need to institutionalize that movement, the Association of Quarters and Slums of Fortaleza (FBFF) was created. Today, the FBFF “comprises 483 organizations dealing with the issues of housing, children’s education, culture, customers’ and health rights” [HOERNING, 2005].

In order to discuss a city planning, it is necessary to know technical concepts and specific terms in the federal, state and municipal legislations. That’s why it is important to train people, what is done by non-governmental organizations. Since 1991, the Centro de Estudos, Articulação e Referência sobre Assentamentos Humanos - CEARAH Periferia (Center for Studies, Integration and Reference about Human Settlings deals with this issue. Another important paper of a NGO is the technical advisement. There are several organizations working with the issue of juridical advisement, for instance: The University Center for Juridical Advisement (CAJU), the Center of Community Juridical Advisement of the Federal University of Ceará (NAJUC), the Service of Popular Juridical Advisement (SAJU) and the Frei Tito Popular Juridical Advisement.

“All these organizations, together CEARAH Periferia, the Central office of Popular Movements (CMP), CEB's, the Archdiocesan Caritas of Fortaleza, the FBFF, the Herbert de Souza Center of Life Defense and the Oficina do Futuro (Workshop of the Future - community ecology) form the network from which we have the Center of Housing and Environment (NUHAB), in partnership with the German Service of Technical and Social Cooperation (DED), the Ecumenical Coordination of Service (CESE) and the OXFAM” [HOERNING, 2005: 5].

There are new NGO’s that are also working with needy communities. The Interdisciplinary Center of Training, Habitability and Social Organization (NICHOS) has been involved in communities in Ceará State through technical advisement and also by training them in issues of comfort, construction and environment. The Association for Co-produced Local Development (ADELCO) deals with issues of habitability in indigenous communities, now in Caucaia and in Maracanaú towns.

So as to guarantee the quittance of the housing developments' installments, the residents created the Housing developments Movement (MCH), an organization that today is important for demanding the improvements necessary for the good operation of the housing developments.

The Organização Popular Habitacional (Popular Housing Organization – OPH), the Movimento dos Catadores de Lixo (Movement of Garbage Collectors) and the União das Associações de Moradores de Fortaleza (Federation of Associations of Fortaleza Residents), which are affiliated with the Central dos Movimentos Populares (Central Office of Popular Movements - CMP), also help with the construction of a more participative city.

Some of those organizations are affiliated with political parties, having a political and party orientation that makes the access to the political debate easier. Such a fact, however, also hinders the unification of forces.

THE ANALYSIS OF THE PROCESS OF PRODUCT DEVELOPMENT

Methods

Initially, we visited the SDLR of Ceará State government, the HABITAFOR of the City Hall of Fortaleza and the CEARAH Periferia. At those institutions we collected information about the projects of social interest houses – SIH, already developed by them, about those currently under implementation and those which they intend to carry out soon. We got information such as: the author of the project, materials and techniques used as well as the financing system. We also aimed at understanding the development process of the housing typologies used by those organizations.

With that information, we have chosen three case studies, one for each institution (SDLR, HABITAFOR and CEARAH Periferia). Then, we have employed the questionnaire of pos-occupation valuation in 20% per cent of the social houses. To defined this questionnaire, we have studied the system of pos-occupation valuation used in the University of São Paulo, by Orstein. We made adaptation changes in the vocabulary and in the critical items assessed by the questionnaire.

The questionnaire developed dealt with the several aspects of housing, such as: adaptation to use and finishing of the items that are common to housing development; appearance; safety; location; conditions of comfort of the housing unit; space of use and finishing of the housing unit environments.

Simultaneously to this quantitative research, we also tried to sketch a qualitative research. We listed the risk areas of Fortaleza and learned about the information record that will be adopted by HABITAFOR and SDLR. With those records, we can include in them questions about the expectations of future users of SIH. That would be a way to obtain the qualitative data.

The data generated both by the quantitative and qualitative research will help with the decision-taking in the development of the project of the social interest housing.

RESULTS

Ceará state government

From interviews with professionals related to both the development of PROURB as to the State Department of Housing, we can notice that the government does not make use of many tools of the process of product development. The housing typologies that are still in use today are result of projects still planned at that time of the former COHAB in Ceará, which was closed down in 1999. And we do not really now how the project was conceived.

Nowadays, in the housing development of Curió, one is already making use of another housing typology. It is a modification of the M10-G2 typology. Such a modification was made based on complaints from the families that already lived in housing units built by the government and from families that were registered and would soon get new houses. However, there is no type of systematization of that information, what would help a lot with the feedback of the project process of those housing units.

Another tool found in the government that could be used as a good source of requirements would be the information record of the families that can get housing units. The record has been modified, leaving only the information that can generate graphs. We can find information on the head of the family, the spouse, other family members, identification of the house where they live today and information on the social relationships that occur or are aimed at in the neighborhood. The record, however, does not have characteristics through which we can collect information on the future users' expectations about their housing.

Regarding the quantitative research, the state supplied different lists about the projects that were conducted since the time of the former COHAB. There was not, however, any unique list. The projects were grouped, then, in only one list with specific information on the housing enterprises, such as: financing system, number of housing units, location, housing typology, stage of work, etc. With that, we could notice that the in the state only two housing typologies were dealt with from the nineties up to the present moment. Except for two housing developments in apartments, all the others were conceived by making use of the band house typology[1]

The important thing is that, from that information, we could choose as a study case: the *Dias Macêdo* project. Then we employed the questionnaire of pos-occupation valuation in 56 houses. We have already analyzed some points of the questionnaire about the relationship between the institution and the people. People think that the number of the meetings and the communication with the SDLR were reasonable. But the maintenance and the control of the building are regular.

City Hall of Fortaleza

At HABITAFOR, the information was more difficult to obtain as the new administration took power only in January. In other words, they are still in the process of internal restructuring. Besides that, the lack of city planning when the city area was divided into administrative sections has caused a lot of information to get lost. As a result, the current administration has at the moment practically no records concerning several aspects, including housing issues.

[1] Housing typology in which houses are built close to one another with no lateral distance between them, with more than two geminate houses.

Nevertheless, we got some important information. Obviously, there is no process of project in the institution. As already mentioned, the housing issue in City Hall of Fortaleza was treated in a decentralized way, with each geographical executive unit of the city meeting its demand the way it wanted without giving any information to other institutions that worked with the housing issue. Besides, there was no systematization of the information.

The current team of HABITAFOR, however, intends to create a project process, not only of the housing units but also of the collective areas, based on people's participation. The project would be designed together with the population, but we still do not know how and when that will happen.

Nowadays, we are still looking for information. The risk areas, as well as the housing developments constructed by collective effort are already known. HABITAFOR has already developed two kinds of information records: one for the families that will still get housing units and another for the families that have already received those units. Those records haven't yet been put into practice and do not contain information on the future user's expectations about the house they will receive and about the satisfaction level of those already living in housing developments.

Even though the difficulties, we could choose a study case: the *Lagoa do Opaia* project. Then we employed the questionnaire of pos-occupation valuation in 104 apartments. With the analysis of the questionnaire about the relationship between the institution and the people, it is cleared that people think that the number of the meetings, the communication with HABITAFOR, the maintenance and the control of the building are not even regular.

NGO

The NGO on which we concentrated our studies was the CEARAH Periferia. According to the collected information, this is the only NGO that really built housing units in Fortaleza. In total, it was five projects. One of them, the one built in Bom Sucesso neighborhood, even had an evaluation after it was built.

Differently from the state government and the City Hall, CEARAH Periferia has a process of project of its housing units. The information is not so systematized in a written way, but there is a photographic record and transparencies that were dealt with in the projects. It makes use of the methodology of the participative design and, therefore, together the community, they accomplish the design of the housing units, of the blocks, and the location of the community facilities. In the end, the project is made by a lot of hands.

However, except for the information collected in the *Bom Sucesso* project, no other project has had a feedback in the project process, at least in a systematic way. And we chose as a study case: the *Bom Sucesso* project, where we employed the questionnaire of pos-occupation valuation in 46 houses. With the analysis of the questionnaire about the relationship between the institution and the people, we could also conclude that people think that the number of the meetings, the communication with the NGO's, the maintenance and the control of the building are not even regular.

EXPECTED RESULTS

Due to lack of information that should be obtained at the institutions, we took more time than we thought could be necessary to reach the above results. Now we are finishing the graphics of the datum collected by the questionnaire. From that on, we will develop feedback tools and a project process that takes into account the requirements obtained at the quantitative and qualitative researches.

CONCLUSIONS

The results reached show the urgency in the definition of a process of development of the product (PDP) both in the state government and in the City Hall of Fortaleza. Even if we don't have the results about the questionnaires, visiting the cases studies, we could find many problems not only with the project execution but also with the project itself. So, we must think about a process of development of the product that includes also the execution field.

The project process used by the NGO CEARAH Periferia can serve as a good base in the construction of the PDP of public institutions. In all of the institutions, however, it is necessary to work with feedback tools of the project process, as well as with the acquisition of requirements that must be dealt with in the project.

The analysis of the questionnaire about the relationship between the institution and the people show us that our analysis made by the interviews in the institutions is correct. In the questionnaire, most of the people say that the number of the meetings, the communication with the institutions, the maintenance and the control of the building weren't done in a reasonable way; the institutions were not so present in the community. This allows us to identify others mistakes in the process of development of the product.

Finishing the analysis of the questionnaires datum, we'll be able to contribute to the quality improvement of the housing units produced by public institutions and non-governmental organizations by the definition of the process of development of social housing, the project process and the feedback tools of the project process.

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Problems Affecting Housing Financing in Southwestern Nigeria

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Abstracts
In spite of its significance, many households (especially in developing countries) are denied access to decent housing as a result of lack of access to suitable forms of credit for housing investment. This paper therefore examined those problems that restrict household access to housing finance in Southwestern Nigeria. Primary data were collected with two sets of questionnaires administered on lenders and borrowers. The sample comprised 170 lenders and 327 borrowers randomly drawn from sample frames of 234 lenders and 467 borrowers. The study showed that in rank order, the three most important problems to lenders were high interest rate and inflation, fund mobilization and affordability while to borrowers, they were high interest rate and inflation, fund mobilization and title deed. Besides the proportion method, data were also analysed by means of two other methods – Relative Importance Index and Principal Component Analysis and they showed comparable results. The study concluded that high interest rate and inflation was the most significant problem affecting housing financing in Southwestern Nigeria. The implication of this is that interest rate and inflation must be seen as very crucial in policies on home ownership, housing finance and delivery which should be properly managed to promote availability and accessibility.

Keywords
Housing financing, mortgage finance, housing financing problems.

INTRODUCTION

Housing is universally accepted as one of the basic necessities of man. Besides, housing investment is usually the largest single form of household wealth and it accounts for between one-quarter and one-half of the capital stock in developed and developing countries (Buckley, 1989). Ibbotson and Seigel (1983) also averred that housing accounts for a larger proportion of the capital stock than of fixed capital formation because of its longer life. All these point in the direction of the significance of housing both to the household and the economy of any given country. Besides the significance of housing, several studies have documented the significance of finance as the pillar, pivot, key, cornerstone and most crucial element in housing investment the availability of which determines access to other key inputs of land, labour, material and infrastructure (Renaud, 1986; Malpezzi, 1990; Tibaijuka, 2002; Boonyabancha, 2002). Adibua (1979) had earlier expressed the opinion that a well conceived grandiose architectural design will perpetually remain a paper dream if there is no finance, to pay for the land, labour and materials that would transform the design into concrete and that housing without finance is an unattainable goal.

Unfortunately, lack of access to suitable forms of credit has always been a major impediment to the provision of housing for low-income groups- the vast majority of urban households in developing countries (UNCHS-Habitat, 1994). According to Renaud (1986), housing finance systems in less developed countries, LDCs, are seriously deficient in their coverage of populations to be served and in the quality of services they provide. The poor, low and even moderate-income households are the majority in developing countries and they cannot afford a loan for the least expensive, commercially built housing units (UNCHS – Habitat, 2002). It is also documented that the institutional sources of housing finance are often inaccessible to most Nigerian households (Falegan, 1985; Olufemi, 1993).

If housing and its financing are that significant as enumerated above, what then are those problems that restrict household access to housing finance especially in developing countries? Specifically, why is housing finance inaccessible to the poor, low and moderate-income households that constitute the majority in developing countries? What is the nature of these problems? What could be done to solve these problems? It is against the foregoing that this paper tried to examine those problems that restrict household access to housing finance in Southwestern Nigeria. The paper also considered empirically how two of the key participants in housing financing rank these problems in order of significance. It suggested measures for solving the identified problems with a view to boosting access of the poor, low and moderate-income households to housing finance. The problem being investigated in this paper has been particularly identified with developing countries. The study area (which includes Lagos metropolis and Ibadan) offers a good example of a region with high population concentration in developing countries that is confronted with problem of housing the urban poor and low-income group. It is therefore reasoned that the findings from this work would have global appeal by being relevant to other developing countries like Nigeria.

REVIEW OF LITERATURE

It has been documented in several studies that high interest rate and inflation have constituted at one time or the other, a major problem of housing financing in countries like US, UK, Hong Kong, Denmak, France, Germany, Chile and Nigeria (Diamond & Lea, 1992; Bramley, 1993; Fu, 2000; Order, 2000; Colton, 2002; Adeoye, 2003). According to Ojo (2004), the quantum of funds available for housing investment in any given country is a function of the level of fund mobilization which in turn depends on the prospects and opportunities from the three approaches identified by Renaud (1986). In this respect, it had even been documented that inadequate funding has become the most important constraint to housing finance in Nigeria (Megbolugbe, 1986; Osanwonyi, 1986). The weak power of enforcement has been identified as a major problem with fund mobilization through mandatory schemes in Nigeria especially under the National Housing Fund (FMBN, 1998).

Studies conducted on households in England, four African countries of (South Africa, Nigeria, Ghana and Tanzania), Zimbabwe, and in many other countries confirm that affordability is a major problem affecting housing financing (especially in developing countries) because it eliminates low-income earners from the housing market (Bramley, 1993; UNCHS, 1994; Moss, 2002). It has been further noted that no other concept is as responsible for the housing crises in developing countries as "affordability" (UNCHS, 1994, p. 8). Studies undertaken on loan recovery activities of public and private housing finance institutions in Kenya, Zimbabwe, Botswana and Nigeria indicate varying results with some recording success stories and some poor performance (UNCHS, 1994; Falegan, 1985; Olufemi, 1993; Ajayi, 1990). In effect, loan recovery/ repayment constitutes a major problem affecting housing financing especially where a financing institution has record of poor or low performance on loan recovery thereby denying new borrowers access to loanable funds.

Renaud (1986) identified two basic models of housing finance systems namely – the British- US model and the Continental – European model with the first model (depository) operating in the primary mortgage market and the second model operating in the secondary mortgage market. Unfortunately, it has been observed that in spite of the attractiveness of the second model, many countries (especially developing ones) do not currently have effective ways of linking lending markets with capital markets (Renaud, 1986; Order, 2000; Colton, 2002). The undeveloped nature of housing finance system as a problem affecting housing financing in many countries (including Nigeria) has also been documented in many studies (Osanwonyi & Megbolugbe, 1987; Olufemi, 1993). There are a number of lender's other eligibility criteria applied by most housing finance institutions which severely restrict the access of low income groups to mortgage loans. These include: minimum (equity) contribution by the borrower (which could vary from 10 to 20 per cent of the house price), provision of additional collateral besides the mortgaged property, taking of adequate insurance cover and possession of current tax clearance certificate (UNCHS, 1994; Olufemi, 1993; Yaya, 2002).

Borrowers are required to have collateral such as titled land, a condition which acts as a major handicap to the poor, and to women as they hardly have the legal right to get titled land in their name in African countries in particular (UNCHS, 1994). According to Diamond and Lea (1992), in many developing countries, issues relating to land title remain a major barrier to housing finance. In Nigeria, the process of procuring title to land under the Land Use Act is very cumbersome and costly in time and money while a prospective borrower under the National Housing Fund Scheme is expected to have a good title to the subject property to be financed from the proceeds of the loan (FMBN, 1998). The right to take over the security for a loan in default is a <u>sine</u> <u>qua</u> <u>non</u> of housing finance and without that ultimate threat to a borrower in arrears, the system would break down (UNCHS, 1994, p. 30). A common complaint from housing finance institutions in developing countries is that legislation is weak and enforcement even weaker when it comes to repossession (UNCHS, 1994, p. 31). Foreclosure and repossession as a problem affecting housing financing is also recognized in Nigeria. Falegan (1985) averred that FMBN had to embark on aggressive campaign to recover the mortgage debts by employing the services of professional auctioneers who advertised and disposed of such mortgaged properties by outright sales.

In the process of government regulatory intervention in areas such as: income and property taxation, subsidy schemes, capital markets, financial institutions, property conveyancing, foreclosure, repossessions etc (UNCHS, 1994) a number of problems are bound to crop up. In his study, Moss (2002) noted that transaction costs in lending to the housing market are usually high and small loans are unprofitable and riskier for a commercial lender. It is being strongly canvassed (UNCHS, 1994) that transaction costs should be drastically reduced especially to enhance the access of low-income earners to housing finance. In Nigeria, this author discovered during the field survey that the PMIs (Primary Mortgage Institutions) are of the view that the rate of 0.5% of the loan value payable by loan applicants is too low relative to the quantum of services they render as a result of which they are clamouring for an upward review of the rate.

From the foregoing review of literature, the problems identified as affecting housing financing are: (i) high interest rate and inflation (ii) fund mobilization (iii) affordability (iv) loan recovery/repayment (v) undeveloped housing finance system (vi) lender's eligibility criteria (vii) title deed (viii) foreclosure and repossession, (ix) government regulatory intervention and (x) transaction costs. These problems have been considered in various separate contexts. This paper has however looked at all these problems within the Nigerian context as they affect housing financing.

THE STUDY AREA

Southwestern Nigeria, the study area for this paper, is highly urbanized and cosmopolitan and is one of the six geopolitical zones of Nigeria covering the following states of the country: Lagos, Ogun, Oyo, Osun, Ekiti and Ondo.The 1991 national census figures put the population of the then five states of Southwestern Nigeria as follows: Lagos (5,685,781), Ogun (2,338,570), Oyo (3,488,789), Osun (2,203,016) and Ondo (3,884,485). Ekiti State was carved out of Ondo State after the 1991 census hence its population figure is sub-sumed in the 1991 figure for Ondo State.
Lagos, in spite of the relocation of the nation's capital to Abuja remains the commercial, financial and business headquarters of Nigeria (Ojo, 2004). A 1985 Federal Office of Statistics survey indicates that Lagos metropolis contains 38.12% of all the industrial establishments in Nigeria, while according to Oladimeji (1995), the metropolis also accounts for 45.1% of total employment in industries. Ibadan which is another major metropolis within the zone is the seat of many educational institutions (including the nation's premier University) and a big commercial center of note even in the West African sub-region. Ibadan is also generally acclaimed as the largest city in black Africa south of the sahara. The headquarters of: 63.29% of the PMIs, 89.89% of the banks and 83.05% of the insurance companies in the country are located in Southwestern Nigeria (Ojo, 2004). The zone experiences high influx of population from other parts of the country and these teeming urban population need housing the financing of which is the concern of this paper. An investigation into the problems of housing financing in the study area is therefore considered expedient and desirable hence this study.

METHODOLOGY

The subjects of study in this work are lenders and borrowers and they constituted the respondent groups for the purpose of questionnaire administration within the study area. The sample comprised 170 lenders and 327 borrowers randomly drawn from sample frames of 234 lenders and 467 borrowers. The sample frame of 234 for lenders is made up of the following key player institutions that are (over the years) engaged in housing financing in the country: PMIs, (50), Banks (89), insurance companies (98) and State Housing Corporations (6). The sample frame of 467 for borrowers group is the total number of individual applicants who have succeeded in obtaining housing loan from the aforementioned lenders group institutions within the study area during the period 1992 to 2000. The sample sizes adopted were 70% of the sample frames and these were quite manageable sizewise. Based on the calculated sample sizes, a total of 170 and 327 questionnaires were distributed to lenders and borrowers respectively. 136 lenders and 305 borrowers questionnaires were duly completed and retrieved representing 80% and 93.3% response rates respectively which appeared impressive. With respect to the time frame adopted for data collection, i.e 1992 to 2000, the year 1992 was chosen because it marked the beginning of major revolution in the mortgage sub-sector of the country's economy with the birth of the National Housing Fund – NHF. Data collection for this work was between June and November, 2003.

From the review of literature, a number of problems were identified as affecting housing financing generally and globally. With respect to the main thrust of this paper, these possible problems were measured by asking the two respondent groups to rank the problems in order of importance on a scale of 1 to 5 with 5 representing very significant and 1 not significant. The main technique of analysis adopted in this paper was the proportion method. The method is a statistical means of representing the significance of a variable relative to all other variables under consideration. Statistically, it is represented by the total score of the variable divided by the overall sum of scores of all variables being considered and is usually expressed in percentage:

Proportion (P) = Total Score of Variable x 100 ………………………………..(1)
Overall sum of scores of all Variables 1

$$P = \frac{\text{Total Score of Variable}}{\text{Overall sum of scores of all Variables}} \times \frac{100}{1} \quad \text{(1)}$$

In table 1, P was derived as follows: sum x 100 and for table 2, P was derived as follows: sum x 100.
136 x 5 305 x 5

The other two methods of analysis adopted were RII and PCA.
Relative Importance Index – RII, is a technique of analysis that rates factors against a scale in order to assess the significance of each factor. The scale is then transformed into RII for each factor in order to determine the ranking of the different factors. RII is computed using the following formula:

$$RII = \frac{\sum W}{A \times N} \quad \text{……(2)}$$

where: W = weighting given to each factor by the respondents, which ranges from 1 – 5 in this study, A = highest ranking i.e. 5 in this case and N = total number of respondents.
The Principal Component Analysis – PCA is mainly used as a tool for data reduction: that is, as a transformation, which shows which parts of the data can be discarded with little loss of information. In addition, it can be used to show which variables can be omitted from the set without changing too much the information base. The PCA technique assigns values called Eigenvalues to each factor, upon which factors with Eigenvalue below 1.0 are discarded as not significant.

RESULTS, DISCUSSION AND CONCLUSION

Table 1: Analysis of Problems Affecting Housing Financing from the viewpoint of Lender
Source: Ojo, 2004

Hypothesized Problems	N	Sum	Proportion (%)	Ranking of Factors
Interest Rate & Inflation	135	666	97.9	1
Fund Mobilization	128	596	87.6	2
Affordability	136	559	82.2	3
Loan Recovery/Repayment	136	554	81.5	4
Undeveloped Housing Finance System	120	522	76.8	5
Lender's eligibility Criteria	136	520	76.5	6
Title Deed	128	469	69.0	7
Foreclosure & Repossession	128	454	66.8	8
Government Regulatory Interventions	136	433	63.7	9
Transaction Costs	136	382	56.2	10

Table 2
Analysis of Problems Affecting Housing Financing from the viewpoint of Borrowers

Source: Ojo, 2004

Table 3

Hypothesised Problems	N	Sum	Proportion (%)	Ranking of Factors
Interest Rate & Inflation	305	1405	92.1	1
Fund Mobilisation	305	1305	85.6	2
Title Deed	305	1255	82.3	3
Affordability	300	1220	80.0	4
Loan Recovery/Repayment	300	1205	79.0	5
Lender's Eligibility Criteria	300	1100	72.1	6
Undeveloped Housing Finance System	305	1005	65.9	7
Transaction Costs	300	990	64.9	8
Foreclosure & Repossession	290	970	63.6	9
Government Regulatory Intervention	305	905	59.3	10

Analysis from the viewpoint of Lenders by means of RII and PCA

Source: Ojo, 2004

Hypothesized Problems	N	Sum	RII	Eigenvalues (PCA)	Ranking of Factors by 2 methods
Interest Rate & Inflation	135	666	2.96	2.655	1
Fund Mobilization	128	596	2.65	2.143	2
Affordability	136	559	2.48	1.515	3
Loan Recovery/Repayment	136	554	2.46	1.116	4
Undeveloped Housing Finance System	120	522	2.32	.958	5
Lender's eligibility Criteria	136	520	2.31	.585	6
Title Deed	128	469	2.08	.481	7
Foreclosure & Repossession	128	454	2.02	.289	8
Government Regulatory Interventions	136	433	1.92	.173	9
Transaction Costs	136	382	1.70	8.634E-02	10

Table 4

Analysis from the viewpoint of Borrowers by means of RII and PCA

Hypothesised Problems	N	Sum	RII	Eigenvalues (PCA)	Ranking of Factors by 2 methods
Interest Rate & Inflation	305	1405	6.24	4.489	1
Fund mobilization	305	1305	5.80	2.276	2
Title Deed	305	1255	5.58	1.467	3
Affordability	300	1220	5.42	1.035	4
Loan Recovery/Repayment	300	1205	5.36	0.678	5
Lender's Eligibility Criteria	300	1100	4.89	0.411	6
Undeveloped Housing Finance System	305	1005	4.47	0.353	7
Transaction Costs	300	990	4.40	0.184	8
Foreclosure & Repossession	290	970	4.31	8.016E-02	9
Government Regulatory Intervention	305	905	4.02	2.576E-02	10

Source: Ojo, 2004

Results of analysis from Table 1 show that high interest rate and inflation, fund mobilization and affordability were ranked as the three most significant problems affecting housing financing from the perspective of lenders. The Proportion Values for the three problems are: 97.9%, 87.6% and 82.2% respectively. Results of the analysis also showed that transaction costs had a Proportion Value of 56.2% and was ranked as the least significant by lenders.

Table 2 documents the results of analysis from borrowers viewpoint. The results show that high interest rate and inflation, fund mobilization and title deed were ranked as the three most significant problems affecting housing financing from the perspective of borrowers. The Proportion Values for the three problems are: 92.1%, 85.6% and 82.3% respectively. Results of the analysis also showed that government regulatory intervention had a proportion value of 59.3% and was ranked as the least significant of all the problems by borrowers.

Table 3 contains the results of analysis of problems affecting housing financing in the study area by means of RII and PCA methods from the perspective of lenders. The two methods also ranked equally: high interest rate and inflation, fund mobilization and affordability as the three most significant problems affecting housing financing from the viewpoint of lenders in the study area. The PCA technique also showed that there were four significant problems affecting housing financing namely, high interest rate and inflation, fund mobilization, affordability and loan recovery/repayment as these were the problems that have Eigenvalues above 1.0. The results of analysis of problems affecting housing financing in the study area by means of RII and PCA methods from the viewpoint of borrowers are contained in Table 4. The two methods also ranked equally: high interest rate and inflation, fund mobilization and title deed as the three most significant problems affecting housing financing. Again, the PCA technique showed that there were four significant problems affecting housing financing namely, high interest rate and inflation, fund mobilization, title deed and affordability as these four problems had Eigenvalues of above 1.0. On the whole, Tables 1 and 3 showed comparable results while Tables 2 and 4 also showed comparable results from the perspectives of lenders and borrowers respectively notwithstanding the different methods of analysis adopted.

A comparison of results of analysis from the perspectives of lenders and borrowers show quite interesting revelations. The two respondent groups ranked high interest rate and inflation as the most significant problem affecting housing financing. They both also ranked fund mobilization as the next most significant problem after interest rate and inflation. Whilst they both agreed on the two most significant problems, they however differed on their perception of the third most significant problem after high interest rate and inflation and fund mobilization. Lenders ranked affordability as the third most significant problem while borrowers saw it as title deed. Again, while lenders ranked transaction costs as the least significant of all the problems borrowers perceived this as government regulatory intervention.

That lenders ranked affordability as the third most significant problem might be explained on the grounds that it eliminates low-income earners from the housing market and that no other concept is as responsible for the housing crises in developing countries as "affordability". Borrowers perception of title deed as the third most significant problem might be explained in terms of its being a major barrier to housing finance for the poor and to women especially in developing countries. That lenders perceived transaction costs as the least significant problem could be due to the fact that a borrower has little or no choice in paying these costs once the loan is approved and he decides to accept the loan. The perception of government regularity intervention as the least significant problem by borrowers might be due to the fact that it has a more direct bearing on the operations of the lenders. On the whole, the need for a further study to investigate the differences in perceptions by the two respondent groups in these two areas might be quite desirable.

A major conclusion from this study is that high interest rate and inflation was the most significant problem affecting housing financing in Southwestern Nigeria. The implication of this is that high interest rate and inflation must be seen as very crucial in policies on homeownership, housing finance and delivery which should be properly managed to promote availability and accessibility. The conclusion reached from this study validates what literature has led us to know earlier. It was stated in the review of literature that high interest rate and inflation had wreaked havoc at one time or the other on housing finance systems of countries like US, UK, Germany, France, Denmark and Hong Kong. This conclusion further confirms the global nature of this problem and in the present study within the context of a developing country. It is imperative for government to decisively address this problem of high interest rate and inflation. Fiscal and other economic policies should be put in place to bring down the high interest rate regime which is being currently experienced in Nigeria. A regime of high interest rate is known to discourage borrowing (thereby restricting access to finance) while at the same making lending an unattractive venture. The problem of inflation should also be decisively addressed. Unfortunately, the raw materials base of most building materials in Nigeria have high import content and this is why for example, it is not easy to control the effect of inflation on prices of building materials. Nonetheless, necessary policies should be put in place to contain inflation as much as possible. Appropriate policy measures should also be put in place with a view to solving all the other identified problems in this study.

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Improving Communication between American Supervisors and Hispanic Construction Workers in the United States

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Abstract
Hispanics are a large and growing part of the United States workforce. The number of Hispanic workers in the U.S. construction industry has been steadily increasing and comprises nearly 18% of the workforce. It is projected that Hispanics will make up 25% of the population of the United States by 2050. This research focuses on developing a training program designed to fit the needs of the construction industry from the American supervisor's perspective. This was accomplished by surveying the contractor's attitudes and needs related to the use of Hispanic workers in their construction operations, developing and delivering a Spanish as Second Language course (SSL), and developing and delivering an additional technical course related to concrete finishing. Results from this study confirm that communication is the main problem experienced by American supervisors on the jobsite. Many American supervisors also use or depend on a link-person (an individual that interprets tasks to the rest of the Hispanic crew) to communicate to the Hispanic crewmembers.

It is anticipated that the courses developed and the training provided will improve the communication channels between American supervisors and Hispanic workers and strengthen the supervisor-worker relationship since the American supervisors will have a better understanding of the Hispanic culture. Once American supervisors participate in the integration effort, the construction industry will see results in terms of increases in productivity, quality, and a reduction of fatalities and injuries among Hispanics in the workplace. Last, these findings could also serve other countries and cultures around the world in solving jobsite communication problems.

Keywords
American supervisors, hispanic workers, integration, training, cultural differences.

INTRODUCTION

Every industry in the United States is facing new challenges of growing numbers of minorities and immigrants speaking their native languages with limited or no knowledge of English. As the U.S. economy continues to expand and the baby boom generation retires over the next 30 years, the need for immigrant workers will increase significantly, creating new challenges that target the U.S. labor force (CNN.com 2001). Numerous industries have already had to contract bilingual employees to communicate to workers, who come from numerous backgrounds. Notably, the Hispanic population has increased at a record-breaking rate over the past decade, becoming the largest minority population; according to 2003 U.S. Census Bureau population estimates (U.S. Census Bureau 2004b). Along with the population increase, Hispanic workers continue to have the highest rate fatalities (4.5/100,000 Hispanic workers) among racial/ethnic groups, as reported by the BLS in the "National Census of Fatal Occupational Injuries in 2003." Furthermore, the construction sector carried the highest number (1,126) of fatal occupational injuries in 2003, especially among construction laborers (BLS 2003a).

The Iowa Department of Transportation (Iowa DOT), along with Iowa State University's Civil, Construction, and Environmental Engineering Department, Associated General Contractors (AGC), and other organizations, are taking action to face these new challenges. With the research and data collected, various courses have been developed that focus on the needs of the heavy/highway sector of the construction industry as it relates to the Hispanic workers in Iowa.

This study offers American supervisors a tool for creating more effective and direct lines of communication to the increasing Hispanic labor force. To reach this goal, a thorough assessment of the needs and interests of American supervisors has to take place. This assessment will include the degree of Hispanic cultural awareness among supervisors, which is a critical factor that influences one ethnic group's perception of another. Some American supervisors embrace the new immigrant culture and others simply reject the new culture unless the immigrants adapt to American culture. The training tools developed in this research will give American supervisors the opportunity to be proactive and participate in the assimilation of the two cultures (Hispanic and American) in the workplace.

LITERARURE REVIEW

Demographic Trends

Due to the rapid growth of the Hispanic population in the United States during the past decade and the increasing population projections, this culture calls for recognition and an understanding of their influence over time in American society. By the year 2025, the U.S. population is expected to reach 419.9 million and Hispanics are projected to make up about a quarter (24.4%) of that total (U.S. Census Bureau 2004a). Hispanics are projected to grow at a much higher rate than any other ethnic group. A number of training efforts and programs have emerged to address the issues that the construction industry is facing today with respect to the growing Hispanic workforce. Nonetheless, a quick and cost-effective solution that fits the industry has not been found or recognized nationwide.

Models of Culture

As part of the literature research, an effort was made to understand culture, its definition, dimensions, and implications. Researchers have developed several models to understand national and organizational cultures: Hall's High-Context and Low Context Cultural Framework, Hofstede's Research on Cultures, and Trompenaars's Dimensions of Culture (Nahavandi 2003). The relevance of these models is that they facilitate understanding of how people communicate with each other and they help define the management styles most appropriate under a given circumstance and job setting. This paper uses mostly the Hofstede model for designing and developing the training courses and is elaborated on further in this paper. Hoftede's terminology for describing national

cultures consists of 5 different criteria, which he called "dimensions" because they occur in nearly all possible combinations. They are largely independent of each other. These five criteria are as follows: individualism versus collectivism, large or small power distance, strong or weak uncertainty avoidance, masculinity versus femininity, and time orientation (Nahavandi, 1997).
Table 1 describes some examples of national cultural values that will help trainers better understand the impact of cultural differences on the jobsite. According to the Hoftede's findings on both the Mexican and American cultures (1983), it is concluded that in the workplace, Mexicans, as subordinates, expect to be told what to do, see hierarchy as an existential inequality, and consider their boss as a benevolent autocrat. Also, because of their collectivism, they see relationships as more important than tasks.

Table 1. Comparison of management styles between Mexican and American cultures according to Hoftede (MGT 503)

Aspect	Mexican	American
Work/leisure	Works to live. Leisure considered essential for full life. Money is for enjoying life.	Lives to work. Leisure seen as a reward for hard work. Money often end in itself.
Direction/delegation	Traditional managers. Autocratic. Younger managers starting to delegate responsibilities. Subordinates accustomed to being assigned tasks, not authority.	Managers delegate responsibilities and authority. Executives seek responsibilities and accepts accountability.
Theory vs. practice	Basically theoretical mind. Practical implementation often difficult.	Basically pragmatic mind. Action-oriented and problem solving approaches.
Control	Not fully accepted, sensitive to being checked on.	Universally accepted and practiced.
Staffing	Family and friends favored because of trustworthiness. Promotions based on loyalty to superior.	Relatives usually barred. Favoritism not acceptable. Promotion based on performance.
Loyalty	Mostly loyal to superior. Beginnings of self-loyalty.	Mainly self-loyalty. Performance motivated by ambition.
Competition	Avoids personal competition. Favors harmony at work.	Enjoys proving oneself in competitive situations.
Time	Deadlines flexible.	Deadlines and commitments are firm.
Planning	Short-term due to uncertain environments.	Long-term due to stable environments.

RESEARCH METHODOLOGY

This research involves performing a thorough assessment of the needs and interests of American supervisors in charge of Hispanic craft workers in order to develop an effective tool that will alleviate the current communication gap and create integration between both populations. American supervisors face many challenges daily at the jobsite, such as time constraints, weather, and many other unforeseen events and factors. Thus, understanding most of these challenges as they relate to Hispanic workers, without ignoring the fact that culture plays a big role, is a key part of this research.

The methodology consists of four parts: (1) literature review on the construction industry, the training available for American supervisors, the Hispanic population in the state of Iowa, and the factors behind the industry setbacks; (2) questionnaire development, data collection, and data analysis and results; (3) development of two training courses: Spanish as a Second Language Survival Course and Concrete Pavement Construction Basics, transferability of courses; and (4) conclusions and recommendations.

Questionnaire Survey

The questionnaire was designed to explore the factors that influence how American supervisors in Iowa's construction industry interact in the workplace with the Hispanic crews. A key issue that affected the sampling approach selected for this research was the availability and willingness of project supervisors to participate. Therefore, a "convenience sample" was decided upon, since the "people who are willing to complete the survey are also available when you need them" (Fink 1998). This sample size was determined using statistics on the number of American supervisors and Hispanics involved in the construction industry in Iowa, provided by the BLS and U.S. Census Bureau. The survey consisted of 35 questions divided into the following four categories: (1) type of training offered, (2) Hispanic cultural awareness, (3) safety aspects, and (4) personal information and preferences.

Data Collection

The data collection was carried out in the form of face-to-face interviews, on the jobsite or elsewhere, and mailed-in questionnaires to construction companies in Iowa willing to collaborate. The companies targeted were those that had a significant number of Hispanic employees within the organization. Of the 30 surveys initially planned, 38 were actually obtained among 15 construction companies in Iowa. Seventeen supervisors were interviewed personally and the rest of the questionnaires were filled out by supervisors on their own. American supervisors did not report any difficulty filling out the questionnaire.

Data Analysis and Evaluation

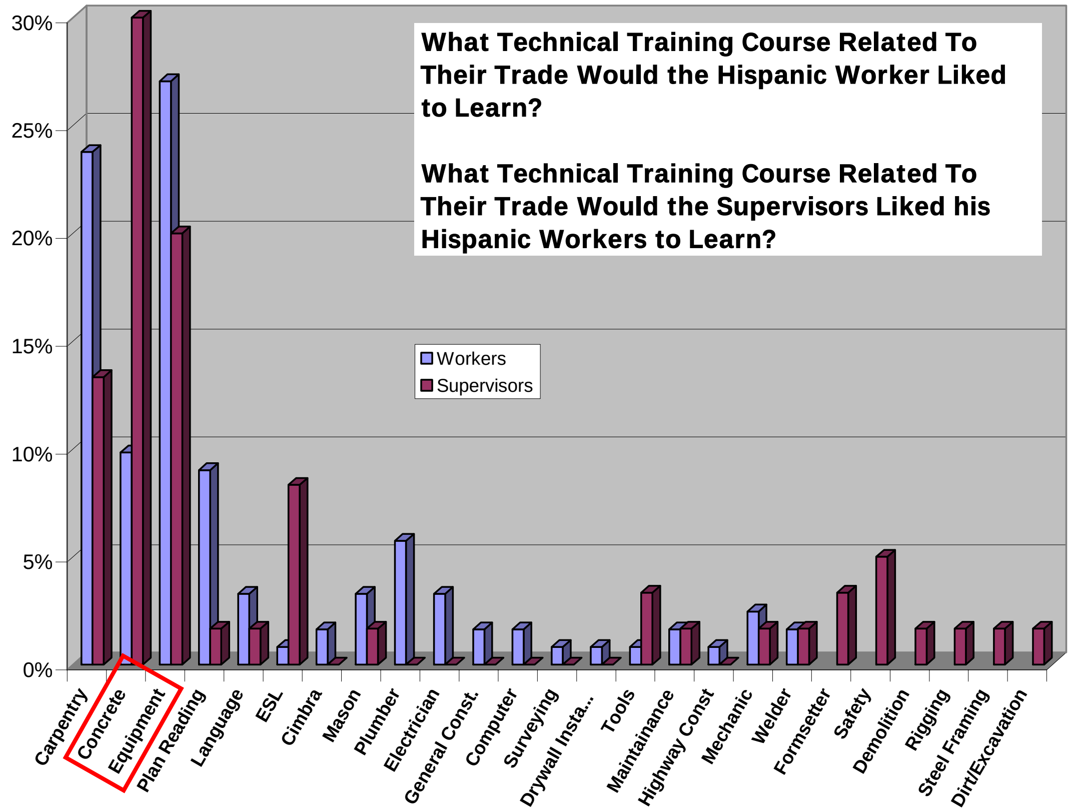
Data analysis and evaluation were completed and used for the selection and development of the training courses. In this part, factors such as the length of the questionnaire, the number of completed surveys, and the data analysis software to be used had to be considered. Each objective in the questionnaire was achieved by asking the appropriate question. Microsoft Excel was used to store respondents' information. Thus, survey responses were input, coded, and kept confidential in a customized database. Totals and respective percentages were calculated, and bar charts were generated for each of the 35 questions. Through the bar charts, the general distribution and the inclination of the data collected were identified. Data analysis continued with the evaluation of the generated charts. Once all the data were gathered, it was exported to the statistical software JMP 5.0.1 to assist with the analysis; results in turn, led to significant conclusions for research project recommendations.

Survey Results

A total of 38 surveys were collected from the American supervisors willing and available to complete the questionnaire. The survey captures the opinions of American supervisors with regard to their Hispanic crewmembers. Over 75% of American supervisors have a link-person (facilitator) who helps them communicate with the Hispanics in their crew. This confirms that many American supervisors are not capable of communicating directly with the Hispanic crewmembers because of language differences. Seventy eight percent of the American supervisors interviewed communicated with Hispanic workers in their crew using the English language. The remaining 22% combined the English and the Spanish language to speak with the Hispanic crewmembers. Eighty four percent of American supervisors are dissatisfied with their ability to communicate in Spanish and 91.6% expressed that it is important to them to improve their communication with the Hispanic workers in their crew. More than half (59.5%) of the American supervisors interviewed have taken some sort of Spanish course in high school or college, but survey results show that their previous education is not enough to communicate clearly with the Hispanic crewmembers, and many indicated that they have forgotten a majority of what they learned. Of the 40.5% who have not taken a Spanish course, 81.3% were interested in taking a course to learn Spanish. When asked what solution they would propose to overcome the language barrier with the Hispanic workers, 15% proposed taking SSL courses and 46% proposed a combination of ESL and SSL courses for both the American supervisors and the Hispanic workers. Evidently, American supervisors recognize that some kind of training in communication skills is necessary to bridge the existing language gap between the supervisors and the Hispanic craft workers.

American supervisors are key players in the activities and processes that take place during a construction project. Hence, their preferences must be taken into account in order to meet their needs and job limitations, such as time. Figure 1 shows that 71.4% of American supervisors who answered this survey question preferred a technical course focused on "Concrete/Finishing" work-related activities. A "Concrete/Finishing" technical course appears to be the most demanded among American supervisors in Iowa.

Fig. 1 Technical course preference



TRAINING COURSES DEVELOPMENT, DESCRIPTION AND CONTENT

Based on available data, results, and recommendations obtained from surveys conducted from May 2003 through March 2004, the research team developed two training courses. One course is called Spanish as a Second Language Survival Course, and the other is the Concrete Pavement Construction Basics. The development of the courses incorporates some of the Outreach Training Program Guidelines from OSHA's outreach training program into the design of these courses. The Concrete Pavement Construction Basics course takes a slightly different training approach, but with the same structural components as the SSL Survival Course. The course was designed to fulfill the specific technical and contextual needs of American supervisors within an appropriate timeframe. Survey results show preferences to be in the area of concrete pavement construction practices. Some of the subtopics developed are concrete placement, finishing, and curing, among many others. These courses not only train for the technical aspect of the job, but include the added value of the language dimension to allow supervisors to communicate with their Hispanic crews without the constant need for a link-person. The link-person is a crewmember who acts as an interpreter between the American supervisor and the Hispanic crewmembers (Canales 2004).

Spanish as a Second Language Survival Course

The intent of these courses is to be highly interactive, provide basic material on only the necessary information, including construction-related vocabulary, tool names, equipment, and simple, direct language phrases to facilitate basic communication. The development of the SSL Survival Courses was based on basic construction vocabulary. The level of these courses, as the name indicates, is for American supervisors with a low level of second language knowledge in Spanish. The survey findings related to SSL courses led developers to structure the course such that it contains two types of instructional materials: a booklet and a visual presentation. The booklet provided to trainees consists of a list of words sorted alphabetically and organized by categories. These categories include general vocabulary (alphabet, vowels, numbers, and hand tools), resources (materials, workforce, and equipment), safety (safety equipment and safety signs), and other information (productivity, quality, and survival phrases). The visual presentation contains pictures of the words and their meanings in English and Spanish.

Instructors also discuss cultural dimensions or cultural differences, which will give Hispanic workers and American supervisors a sense of confidence in the instruction that goes beyond simply pronouncing the word correctly. By discussing the cultural dimensions as described by Hofstede (1983), participants become sensitized to the fact that people are all different, that cultural diversity exists, and that people are somehow located in, belong to, or behave in one or more of Hofstede’s dimensions. For example, in the dimension of power distance, workers from cultures with high power distance believe that the boss is an all-powerful person to whom workers cannot even dare to speak; in such a situation, communication basically does not exist.

Concrete Pavement Construction Basics

The Concrete Pavement Construction Basics course is designed to meet the technical communication needs of American supervisors with Hispanic crewmembers. The course follows the same structure as the SSL Survival Course, but the general approach is modified to address the time limitations that American supervisors exhibit and appeal to the individual interests in work activities for particular road construction projects. The course is divided into 12 subtopics related to concrete pavement construction practices. Three subtopics were initially designed during the early stages of the Hispanic Workforce Research Project to determine the most adequate approach to these technical courses. These subtopics are as follows:

1. Materials 2. Jointing 3. Joint Sawing and Sealing

All three courses contain extensive information and images describing design details and proper procedures for each of the three subtopics. After a pre-test during the early stages, these courses were determined to be too detailed, considering the language limitations of the concrete pavement construction practices for American supervisors. As a result, the remaining nine courses were developed to address simple terminology common on the jobsite. The nine subtopics are as follows:

4. Curing 5. Equipment 6. Finishing 7. Grading 8. Hand Tools 9. Placing Concrete 10. Safety 11. Stringline and Dowel Bars 12. Transporting Concrete

Furthermore, all subtopics have a set of “Basic Survival Phrases” to encourage communication between both parties and a set of “Emergency Phrases” that American supervisors can use for emergency situations. These phrases are repeated in every course because their sole function is to help American supervisors communicate and understand their Hispanic crewmembers.

TRAINING COURSE EFFECTIVENESS

Once the SSL Survival Course was completed, the next step was to deliver the course and test its effectiveness. The course has been delivered successfully two times with the help of the Associated General Contractors of Iowa, either as an eight-hour session on a Saturday or as shorter sessions scheduled during weekdays to fit the needs of the construction organization.

A course evaluation sheet consisting of 22 questions was given to the participants at the end of the training session. The objective of the course evaluation was to determine the adequacy of the course content and the course's usefulness to the American supervisors. The instructor and assistant are also evaluated on their training skills. Through the course evaluation, effectiveness can be measured and improvements can be incorporated into the courses in the future. At the time the course was delivered, two course evaluations were collected.

In general, the results show that the SSL Survival Course was successful in providing these two American supervisors a tool to overcome the communication barrier with Hispanic craft workers in their crews. Still, many difficulties were encountered throughout the scheduling process of the course. There is interest and need for the courses, as discussed in previous sections, but time seems to be a major constraint. The length of the course (eight hours) seems to be a limiting factor for American supervisors and construction companies in Iowa, since there was a very low sign-up and attendance rate for the SSL course.

The CPCB Course was successfully delivered in April 2005. A total of five people described as "foremen" and one "field supervisor" attended the training session. The subtopic selected by the construction organization for this session was Safety, and it lasted approximately two and one-half hours, followed by the course evaluation questionnaire. This questionnaire follows the same format as that previously discussed for the SSL Survival Course.

The results show that the course content was considered appropriate and easy to follow by all the participants. Most, if not all, of the information presented during the course was useful to 66% of the participants. For the training session in general, more than half of the participants regarded the course a worthwhile investment. In some cases, their confidence in speaking Spanish improved, since they repeat the vocabulary terms several times and practiced the correct pronunciation. Almost all of the participants would definitely recommend this course to others. The course material had ratings that ranged from "Average" (33%) to "Excellent" (67%). When asked what information they considered to be the most useful, they answered "survival phrases," "learning the correct pronunciation" and "all of the vocabulary."

In general, the results show that the SSL survival course was successful in providing the two American supervisors a tool to overcome the communication barrier with Hispanic craft workers in their crews. The SSL course content was regarded as "About right;" and "Most" of the course content was determined useful by the participating American supervisors. The construction focus implemented into the course seems to meet the expectations and usefulness of the intended audience (American supervisors). Questionnaire results show that the CPCB Course was successful in providing American supervisors a tool to encourage direct communication with Hispanic craft workers in their crews.

Transferability of Courses

Transferability of the model presented in this paper can exist at both the cultural and language levels independently and interchangeably. For instance, the French economy has experienced immigration mostly from citizens of its former colonies (i.e. Algeria) in the last decades. These French immigrants do not experience the language barrier problem, but come from different backgrounds and cultures. Conversely, another problem could be found within the same country. The two main languages in the People's Republic of China are Mandarin and Cantonese and even though there are cultural differences among ethnic groups in China, this paper's model for creating language training courses could be useful when developing courses that aim to increase technical communication at the jobsite in a specific language. Last but not least, the problem in which both barriers (language and culture) happen interchangeably happens here in the state of Iowa also. Even though the Hispanic population outnumbers them, there is a growing Bosnian minority population in Iowa. Strong evidence exists that the research model for Hispanic workers can be transferred to groups like Bosnian construction workers. It is very important to keep in mind that the final objective of this research is to promote integration at the jobsite between the immigrant worker, in this case Hispanic, and the supervisor, in this case American.

CONCLUSIONS AND RECOMMENDATIONS

As part of the analysis and evaluation of the survey results, the data from the Hispanic workers were taken into consideration. The survey results suggest that the following conclusions are a practical representation of the American supervisors' attitude toward the Hispanic workforce in Iowa's construction industry:

- Communication poses a crucial problem on the jobsite.
- A link-person is commonly used as means of communication.
- The language that American supervisors mostly use to communicate is English.
- Many supervisors are unsatisfied with their ability to communicate to Hispanic crews.
- Many supervisors are interested in taking a course to learn basic Spanish construction terminology.
- Most supervisors propose both ESL and SSL courses to solve the language barrier.
- Most American supervisors prefer a "Concrete/Finishing" technical course to help them better communicate with Hispanic crewmembers.

In conclusion, it would be quicker, more cost-effective, and easier to train American supervisors in Spanish because they are fewer in number and have higher educational levels, guaranteeing that most of the information transmitted in a course will at least be received. More importantly, they are leaders of the crews that perform the actual work needed to complete a construction project. The supervisors need to communicate effectively to increase efficiency and productivity and minimize misunderstandings. Their active involvement in the integration effort will present tangible results and bridge the communication gap.

For the success of these courses, it is recommended that the course be delivered by individuals who possess multicultural experience in the construction industry, specifically Hispanic and American culture, and who are fluent in both languages. This will provide the students a good understanding of the differences between the two cultures and encourage interaction in the classroom through real experiences. The courses must also fit the contractors' work schedules or seasons. For example, training programs in Iowa are best scheduled before the spring season.

These courses are mostly suited for those construction companies that employ a large percentage of

Hispanic workers and work mostly in concrete pavement construction. Those American supervisors who have Hispanic crews should take at least four, if not all, of the Concrete Pavement Construction Basics course that best fit their needs. Contracting companies should be the driving force behind the implementation of these training programs, since upper-management involvement and support plays a big role in the success of the program.

This research is relevant to a vast number of construction organizations not just in the United States, but around the world. This paper compares and contrasts the cultural and language factors involving the immigrant laborer and how it relates to construction safety, productivity, adaptation and communications issues. Around the world, different economic sectors and industries suffer from communication problems similar to the ones faced by the construction industry in the United States. The authors hope that this research will help improve communication between supervisors and construction workers who speak different languages and come from different cultures.

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A virtual learning system to improve technical education in developing countries

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Abstract
The educational sector in Europe is oriented to a process of radical restructuring with the aim of obtaining integration among degrees, a better education quality and more chances to improve and update the knowledge. This article introduces a virtual learning method (WINDS) for technical studies through the usage of the new technologies. WINDS-Web based intelligent design system is the result of a RT&D Project from the IST Fifth Framework Work Programme with the aim to reform education by developing new curricular and pedagogical models. Experiences gained during the experimentation phase on a real world university teaching scenario are also reported in this paper. First results encourage involving this learning methodology to the current University studies. In developing countries with reduced resources Virtual Learning Systems offer an opportunity but, at the same time, they need an investment in the technical and administrative infrastructure.

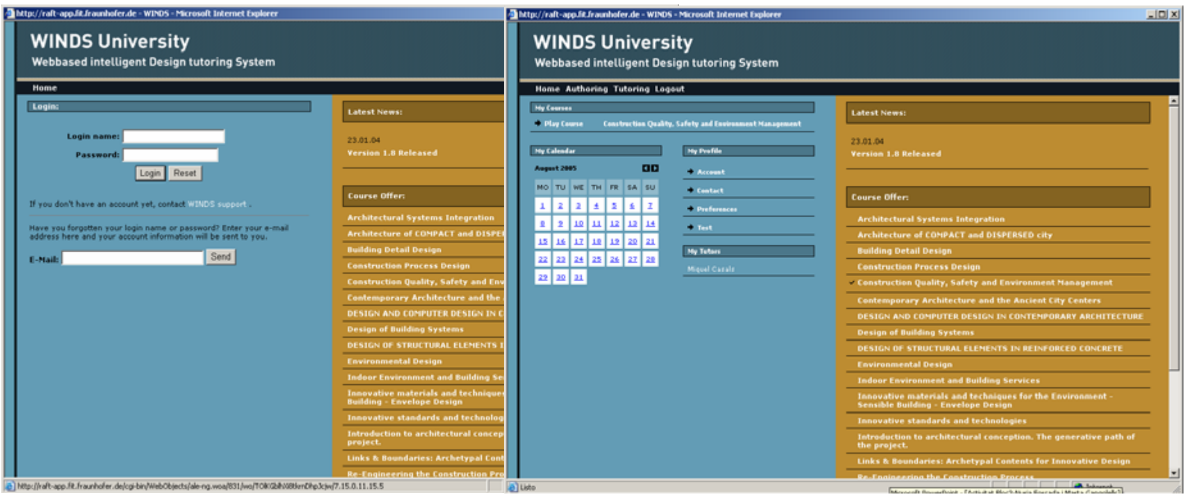
Keywords
Teaching/learning strategies, virtual university, WINDS.

INTRODUCTION

The main objective of WINDS (Web-based Intelligent Design and Tutoring System) project was to contribute to the reorganization of the pedagogical, cultural and functional aspects of design education at the university level. WINDS project was oriented to fulfil the requirements of Flexible University, defining new approaches to design teaching, implementing flexible learning services for university education and constructing large scale experiments in order to promote cultural integration.

WINDS project has developed a networked design tutoring environment which provides the typical university's educational resources like administration office, courses, teachers, reviews, co-operation, libraries and so on. The system gives access to services through the Internet by means of shared instruments, web-browsers and commercial CAD systems. It promotes co-operation between students (peer tutoring) and between students and teachers (remote tutoring) by means of groupware tools [Fitzgerald 1985]. The system can also autonomously assist students during design courses by means of expert systems and intelligent tutoring, which are based on well established pedagogical models. In this paper, our experiences using WINDS platform will be described. Experiences gained during the experimentation phase on a real world university teaching scenario (in the Technical University of Catalonia) will be also reported in this paper.

Fig. 1 WINDS System entry.



DESCRIPTION OF THE WINDS SYSTEM

WINDS platform

The WINDS platform (developed inside the Consortium by FIT- Fraunhofer Institute for Applied Information Technology) is based in an Authoring and Learning Environment (ALE) and it is aimed to design teaching. WINDS platform includes contributions from twenty one European universities from 10 different countries, structured in three departments: Department of Architectural Design, Department of Environmental and Building Technology and Department of Construction Management. All these courses can be accessed in http://winds.gmd.de (see figure 1).

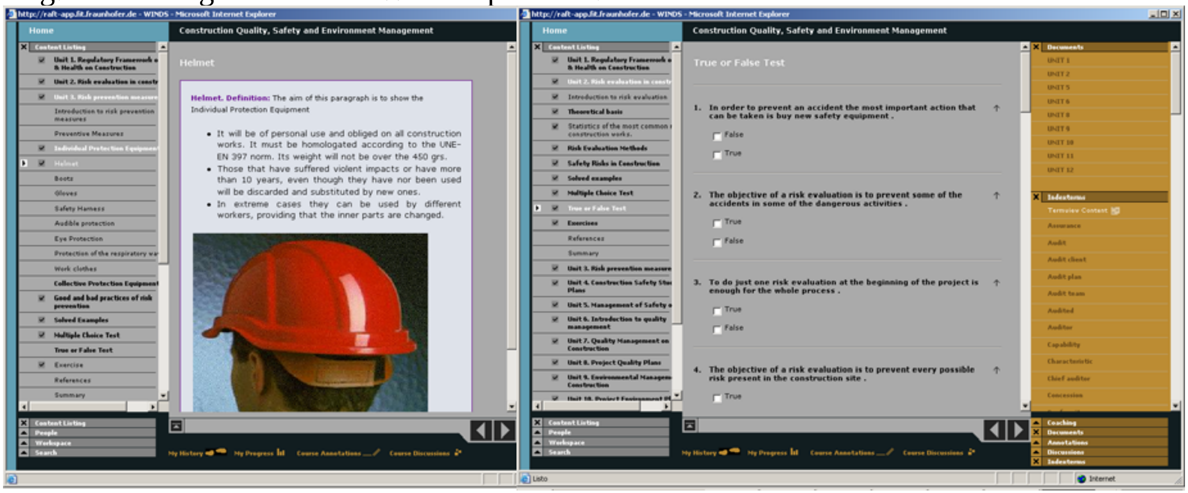
Learning Environment

Courses in WINDS platform are made up of Learning Objects, which can be defined as files aimed to structure the learning material. Learning Objects can be classified in three different topics: Course Units, Learning Units and Learning Elements. Course Units are top-level elements that only have subunits. Learning Units configure and structure the content of a Course Unit. Learning Elements are the basic information fragments of the platform and they can be classified into three subgroups: paragraphs (including the contents of the course), exercises with the practical part of each course and true of false tests and multiple choice tests to asses the acquired knowledge

The variety of Learning Elements is huge (see figure 2), allowing a better adjustment of the form to the content. For example, we can find different kind of paragraphs like simple text paragraphs, picture paragraphs and movie paragraphs. Multiple choice tests and true of false tests can also be created using Learning Elements.

To enable the maximum reusability of the information, each Learning Object has an associated metadata (see Authoring Environment for further details). Furthermore, all the Learning Objects of a course are linked by an Index Terms defined by the author to unify definitions and extend information of each course.

Fig. 2 Learning Elements in WINDS platform.



Index Terms

Index Terms provide means to inter-relate heterogeneous course contents and to find individualized paths through learning materials. Index Terms includes all the relevant concepts contained in all types of Learning Objects. Main concepts are defined and connected (by expressions like "is a", "is a part of", "related to" …) to another concepts defined in the Index Term. These relations can be also expressed in a graphic way. Index Terms also allow finding occurrences inside the Learning Objects, which are displayed highlighted (see figure 3). Index relationships are the base of WINDS reasoning processes.

Fig. 3 Index Terms in WINDS platform.

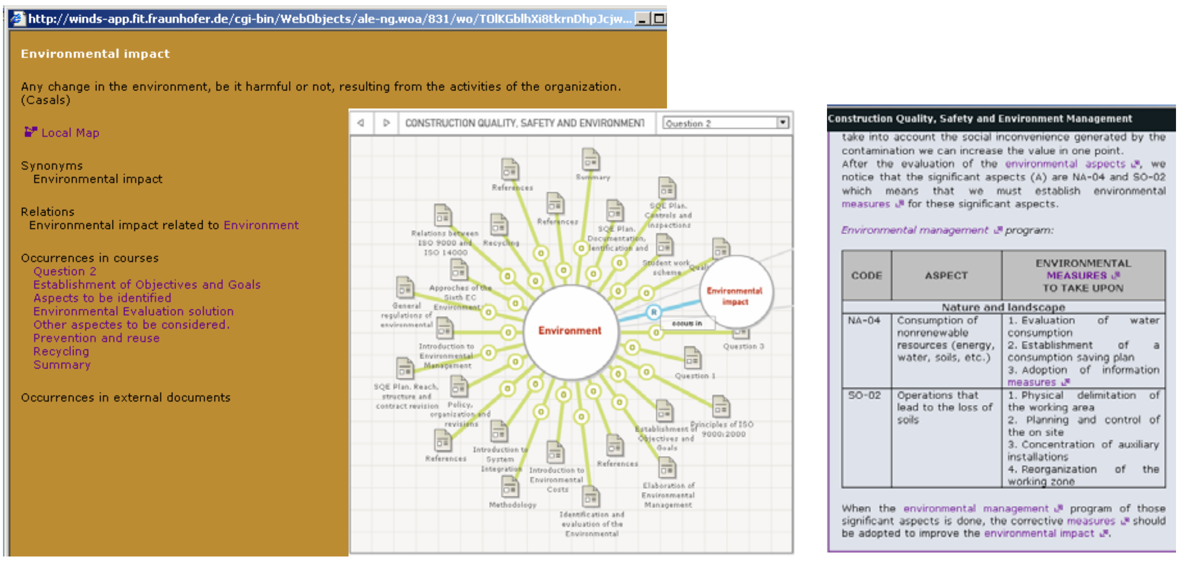
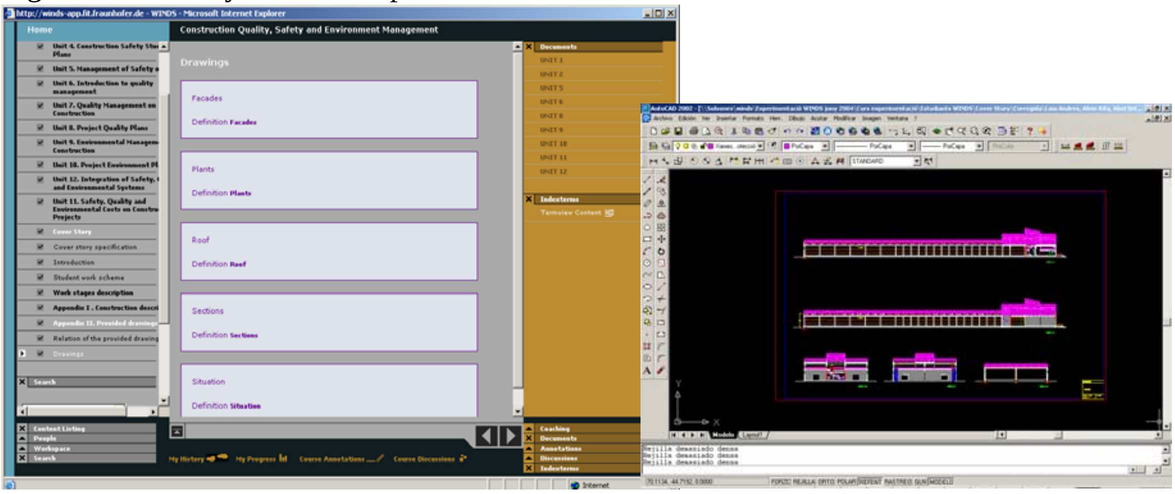


Fig. 4 Cover Story in WINDS platform.



Cover Story

The basic approach is task based teaching and can be defined as follows. The competence set, taken as the backbone of the teaching outline, can be arranged around a general design task that is to be performed by the learner [Schank, 1992]. WINDS calls this task the Course Cover Story. The teacher creates a cover story for the course, assigning a challenge to the students that embody the output of the professional competence to which the course is targeted. Most of the training will then be focused on providing the trainee with the information and tools he needs to achieve the goal. This is to say that competence analysis greatly helps the teacher in designing goal-oriented learning courses, rather than expository teaching ones.

Collaborative Space

Collaborative space is an application software that integrates work on a single project by several concurrent users at separated workstations. In WINDS project, the Collaborative Space is established on a BSCW (Basic Support for Cooperative Work) system (developed by Fraunhofer FIT and OrbiTeam Software GmbH) and consists on the virtual space where to establish contact among students, students and teachers and teachers. Collaborative Space enables users with accesses to the server to view, upload and download documents, post messages, … and therefore the teacher has the possibility to follow the progress of student’s works. Collaborative Space can be directly accessed from WINDS Learning Environment. Another cooperation facility in WINDS platform is the possibility to create private and public annotations related to the whole course or to a particular Learning Object. Users can also start discussions or contribute to the existing ones, which can be related to the whole course or to a particular Learning Object [Kumar et al. (1998)].

Collaborate Software

The platform also includes an interface called 'Collaborate' (developed by Nemetscheck), which allows the interaction teacher-students in a fast, easy and dynamic way [Taylor and Walford (1978)]. It allows a total interactivity and also in real time.

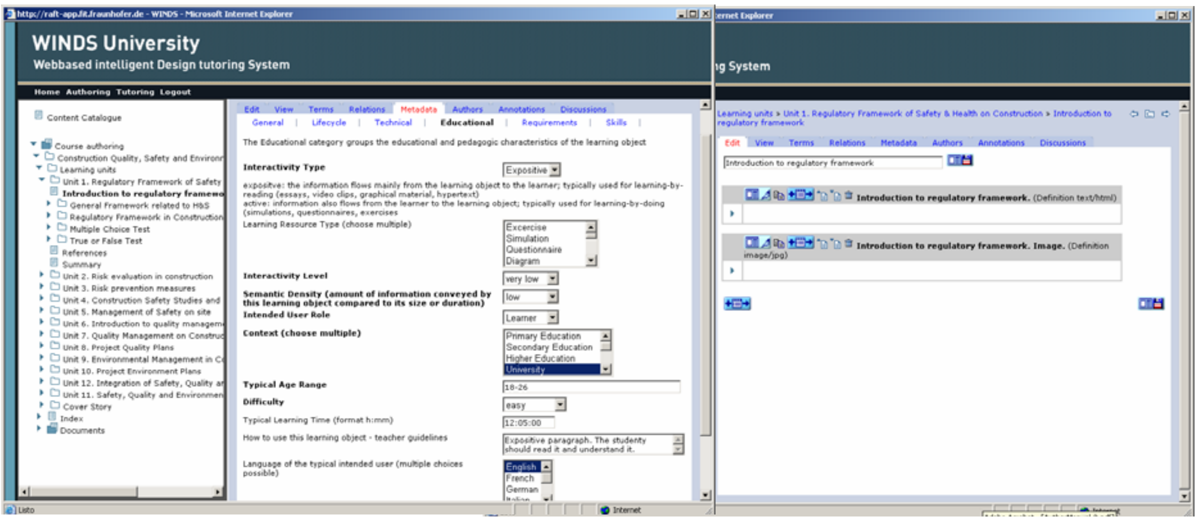
Authoring Environment

The authoring interface gives an overview of all courses authored. In the Content Catalogue, all the learning elements created by the author can be listed as well as the index term, which defines and connect the main concepts exposed in the Learning Elements. Documents, which are supplementary sources of information relevant to the course, can also be registered in the authoring environment.

When creating a new Learning Object, the following forms are provided:

- Edit to add, move, copy, disconnect or delete Learning Objects in the structure and modify its content.
- View to display the learning objects in the same way like students will see them in the Learning Environment.
- Terms to show terms entries highlighted and displaying the corresponding term descriptions and relations on demand.
- Relation to specify prerequisites to this Learning Object.
- Meta data to provide information under six categories related to Learning Objects. The General category includes general information like content description or key words that describes the Learning Object as a whole. The Lifecycle category includes the features related to the history and current state of this Learning Object and those that affect this Learning Object during its evolution. The Technical category includes the technical requirements and characteristics of the Learning Object, like format, size, location,…. The Educational category involves educational and pedagogic characteristics of the Learning Object, such as interactivity level, semantic density, … The Requirements category states groups the intellectual property rights and conditions of use for the Learning Object. Finally, the Skills category includes information related to which competencies will contribute to acquire this Learning Object.
- Authors to specify each Learning Object authorship
- Annotations to create a new annotation about the current Learning Object.
- Discussions to start discussion about the content of the current Learning Object.

Fig. 5 Authoring environment in WINDS platform.



Tutoring Environment

In the Tutoring Environment, teacher can see the list of students enrolled in the course and the state of their progress (see figure 6). It is possible to view which learning objects have been visited and if the student has correctly answered the true/false tests and multiple choice tests. The system also compiles detailed information about the total number of learning objects visited by the student, the number of connections to the WINDS platform and its mean and total duration.

VALIDATION OF WINDS PLATFORM

The role of evaluation is fundamental in the field of a project such as WINDS as it represents an instrument that is indispensable in the project's validation process and in the certification of its didactic effectiveness.

Validation of WINDS platform was carried out in several universities at the end of year 2003. Two basic domains of experimentation were stated for the validation of the WINDS platform: External comparison (which aimed to compare WINDS courses with traditional courses) and Inner functioning, which was focused on assessing the quality of the WINDS platform).

In the Technical University of Catalonia (UPC), the experimentation was proposed to the students at the beginning of the academic official course (2003-2004). Among the requested requirements to participate in the experiment were stressed the necessity of an internet position from home or alternatively a position of internet available inside the faculty and with adequate software support adapted to work on line. Furthermore was stressed the requirement of a sufficient knowledge of the English language. Two groups of students were formed: the traditional group (made up of 6 students) and the WINDS group (made up of 8 students). The experiment required that during the same period the WINDS group worked on line while the students of the regular academic course developed the same topic in traditional lessons. During the experimentation period the WINDS group of students did_not contact colleagues and teachers. All the communication was managed through the winds resources (ALE, BSCW, Collaborate).

Fig. 6 Tutoring environment in WINDS platform.

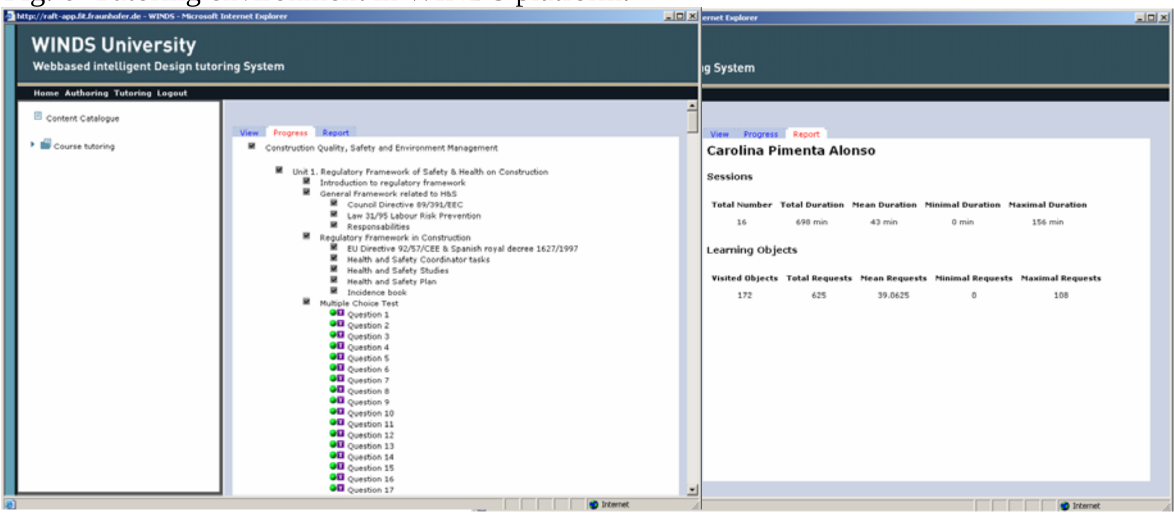
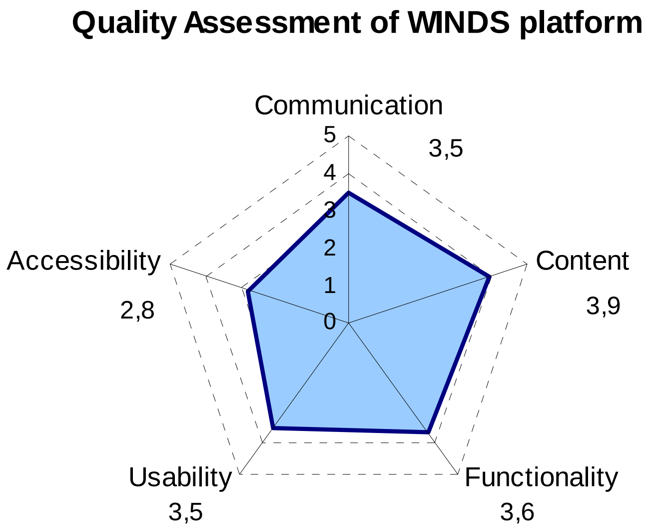


Fig. 7 Evaluation of the inner functioning of WINDS platform in the Technical University of Catalonia.



Students from UPC focused on three lessons of the course “Quality, safety and environmental management” and on the Cover Story, which was shortened and adapted to the particularities of the experimentation phase. At the end of the period of study, corresponding to an equivalent amount in time of three didactic units, all the students answered the Multiple Choice Tests and the True or False Tests. In fact, in the tests of WINDS platform it is possible to reiterate the test several times until the right answer is given, so a student can try out the system until the check of the chosen option is fully correct. Therefore, this learning resource offers mayor opportunities of learning to the WINDS students compared with other students that can obtain less feedback from a multiple choice test.

After the exposition period, all UPC students developed in pairs the graphic exercise exposed in the Cover Story. WINDS group used the Collaborative Space in order to develop and deliver its graphic exercise. Exercises from both groups were corrected by an external teacher who was unable to distinguish between the traditional group and the WINDS group. After evaluating and ranking in a scale of ten numerical degrees (from 1 to 10) the graphic exercises, the evaluator concluded that no difference can emerge from the blind evaluation. Therefore we can conclude that the learning output of WINDS do not differ from the one of traditional courses.

In order to assess the inner functioning of the WINDS platform, WINDS students from UPC were asked to complete a questionnaire (developed inside the Consortium project) based on 29 items related to Communication, Content, Functionality, Usability and Accessibility features. In each item of the questionnaire the user had to express his agreement on a given statement, using a 5 point scale. Results obtained in the Technical University of Catalonia are presented in figure 7.

Analyzing the results obtained from the questionnaires filled by WINDS students in the Technical University of Catalonia we can conclude that the information content of WINDS is relevant, complete and reliable. In addition and according to WINDS users, information design is appropriate. Functionality features sums up all the aspects concerning the interaction between WINDS and its end-users. As functionality have obtained in the questionnaires a score of 3,6 we can conclude that WINDS functions are adequate to reach WINDS educational goals. Attending to the usability, WINDS platform has also been well assessed by WINDS students. This means that this system allows students to reach their educational goals, with no much efforts and time devoted to this task. According to WINDS end users, accessibility is at the time the poorest feature in the platform. Problems in connecting with WINDS server are the most alleged reasons by the students.

CONCLUSIONS

In this paper, main characteristics of WINDS System, which provides a new methodological approach to design teaching, have been exposed. The experimentation phase allowed authors to conclude that it is possible to use web platforms for Virtual Learning of design courses as its didactic effectiveness has been successfully tested in the Technical University of Catalonia.

First results encourage involving this learning methodology to the current University studies for developing countries with reduced resources as nowadays knowledge is a prerequisite for economic growth and development. The speed by which new knowledge, new practices and new products appear in the market makes necessary a personal commitment to learning throughout our whole lifetime. Virtual learning will be a fundamental learning strategy for initial education, as well as for updating of the populations’ knowledge and skills in the economy of the Information age.

Virtual Learning Systems such as WINDS offer to developing countries both an opportunity and a challenge because it would be misleading to suggest the distance education can be used in developing countries without investing in the technical and administrative infrastructure.

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Labour Mobilisation in the Construction Industry

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Abstract
The practice of engaging labour through intermediaries (often referred to as 'outsourcing') is widespread in the construction industries of developing countries. The outsourcing of labour is generally believed to lessen the degree of control that the main contractor can exert over the labour force and hence over the quantity and quality of output. However, a review of recent studies commissioned by the author in sub-Saharan Africa and South Asia reveals a variety of forms of engagement of both the intermediaries and the individual workers. It is shown that workers are commonly associated in groups where they acquire skills and are hired through their leaders. A distinction is drawn between the gang leader and the labour contractor. Both are well developed in Asian countries and currently emerging in sub-Saharan Africa. It is suggested that the particular form of engagement adopted will depend upon the nature of the project, in particular the extent to which close direct control by the main contractor is required, but also by the level of development of the local contracting industry.

Keywords
Employment, labour, construction, Africa, Asia

INTRODUCTION

The basis on which labour is engaged in the construction industry has profound implications for productivity, quality and skill development. These are issues of direct interest to construction managers, as well as to those concerned with the broader development of the industry. This paper looks at the mobilisation of labour in construction in less developed countries, with a focus on a small number of countries in Asia and Africa.

A review of the literature reveals that construction labour is most commonly engaged in these regions through intermediaries. Employing labour through intermediaries offers many advantages. But it may lessen the degree of control that the contractor (or the client where there is no contractor) can exert over the labour force, and hence over the quantity and quality of output. Control over output can be exercised directly through close supervision or indirectly through a contract with a labour supplier that has appropriate incentives written in. The particular form of engagement of the intermediary, as well as the terms on which the labourers are employed, will affect the nature and extent of the control that the contractor can in practice exercise. These are therefore key issues in the management of the construction process.

The paper first documents the predominance and growth of the practice of outsourcing labour in the construction industry in the developing world. The literature is then scanned for evidence of the different forms of engagement of the subcontractors and other intermediaries. Attention is focused on a study of construction labour in Korea and more recent empirical research in Nepal, Kenya and Tanzania. The concluding section summarises the alternatives and comments briefly on the implications.

THE PERSISTENCE AND GROWTH OF LABOUR OUTSOURCING

The recruitment of labour through intermediaries (often referred to as labour contracting) is a long established practice in the construction industry in many developing countries. The intermediaries who recruit and control the workforce are known by a variety of names: *mistri* or *jamadar* in India, *kepala* in Malaysia and Singapore, *oyaji* in the Republic of Korea, *Naikea* in Nepal, *gato* in Brazil, *maestro* in Mexico etc. Although they may take on varying levels of responsibility, their function is essentially the same. They bring labour to the construction site when it is needed and take it away when it is no longer required. Thus they constitute a bridge between the labourers seeking work and contractors or subcontractors who can offer work [Vaid (1999)].

A report prepared by the author for the International Labour Organisation [ILO (2001)] documents the predominance of labour outsourcing in the construction industry in a large number of developing countries. Drawing on an extensive literature, it is shown that the practice is deeply embedded in India [Vaid (1999), van der Loop (1992)] Malaysia [Abdul-Aziz (1995)] Korea [Yoon and Kang (2000)] Singapore [Debrah and Ofori (1997)] Philippines [Yuson (2001)] Egypt [Assaad (1993)] Nepal [Jha (2002)] Brazil [Saboia (1997), Zylberstajn (1992)] and Mexico [Connolly (2001)]. It has also developed in China following the launch in 1984 of a reform programme in the construction industry entitled '*Separation of management from field operations*' [Lu and Fox (2001), Sha and Jiang (2003)].

Evidence is presented in the same report of an increase in the practice in some countries in recent years, as workers who had previously been employed directly on a more permanent basis, have been laid off and re-employed through subcontractors [ILO (2001)]. For example, analysis of data from the national household survey in Brazil shows that construction employees registered with the Labour Ministry (assumed to be the permanent staff of contractors) fell from 41% of the construction workforce in 1981 to 21% in 1999, while unregistered and self-employed workers rose from 57% to 75% during the period. At the same time there was a big expansion in the number of employers, most of them believed to be labour contractors or *gatos* [PNAD (1999)].

More recent studies in sub-Saharan Africa show a similar decline in the permanent, directly employed workforce and a corresponding increase in the number of workers employed through subcontractors. A study of construction labour in Cape Town found that almost all of the workers on construction sites around the city were employed by subcontractors and two thirds of the employers were labour-only subcontractors [English (2002)]. The third who were supplying both labour and materials were in turn outsourcing their labour requirements to labour only subcontractors. Further evidence of contractors having recently shed their directly employed labour in favour of outsourcing lay in the fact that many of the employers of labour had previously been employed themselves in larger construction companies and had been retrenched . They are now supplying labour to their previous employers [English (2002)].

Similar developments can be detected in other countries of sub-Saharan Africa. Published data in both Kenya and Tanzania show employment in the construction sector to have stagnated or declined, while informal sector surveys have picked up a large and increasing number of construction workers in enterprises with less than five or ten employees [Wells (2001), Wells and Wall (2003), Wachira (2001)]. This apparent shift in employment to very small enterprises suggests that the larger contractors operating in these countries also have shed their directly employed workers and resorted to subcontractors and other intermediaries for their labour supply. Recent studies from both countries confirm that construction workers with some skills (known locally as *fundis*) are now acting as labour suppliers to larger firms, with whom they may once have been employed and from whom they learned their skills [Mitullah and Wachira (2003), Mlinga and Wells (2002), Jason (2005)].

DIFFERENT FORMS OF ENGAGEMENT OF LABOUR

Although the brief summary above demonstrates the importance to the construction industry of the practice of outsourcing labour, there are very few studies which delve in greater depth into the details of outsourcing arrangements. This section draws on a study of labour outsourcing in Korea and on three studies commissioned by the International Labour Organisation (ILO) in Nepal, Kenya, and Tanzania. The ILO studies focus on labour in the building industry in major cities where the *informal construction system* prevails. In the informal system no contractor is involved and the client provides the materials [Wells and Wall (2003)]. However, the practice of outsourcing labour is well established in these countries and the methods of engaging labour are believed to be similar in other sections of the industry. Hence the findings reflect the general patterns of construction employment and not just in the building sub-sector in the cities.

Labour outsourcing in Korea

A study by Yoon and Kang [2000] of construction labour in the Republic of Korea examines the various ways in which labour can be controlled and compares 'bureaucratic' forms of control of directly employed labour with control through external contracts. The authors argue that it is difficult to develop an internal labour market and bureaucratic control system in the construction industry, owing to the dispersed nature of sites, the craft basis of production and need for flexibility. In this context, the Korean construction industry has developed a unique system of labour control. The system has two tiers with a bureaucratic control system for the core labour force of white collar workers and a temporary employment strategy and 'commission control system' for the blue collar workers. While some general construction firms do hire manual workers directly, most sublet the construction work to specialist firms according to the type of work. These specialist firms then itemise the work and sublet the items again to small construction companies. The process may go through 4 or 5 stages, creating a multi-layer contracting system. The last contractor in the system, the one who supplies the labour, is generally a skilled manager-cum-worker and is called '*Oyaji*', meaning '*father*' [*ibid*].

Most *Oyaji* have a number of workers more or less permanently attached to them. Their number may be expanded as required by drawing on neighbourhood and kinship ties. Additional workers can also be mobilised through the on-the-spot labour markets which exist in all towns. Skill is acquired informally within the group. Those without attachment to a group generally remain as unskilled labourers and may drift in and out of the construction industry [*ibid*].

There are broadly two types of contract between the subcontractor and the *Oyaji*. The most usual is for the subcontractor to pass the responsibility for completing the item of work, including responsibility for supervision and management, to the *Oyaji*. The contract with the *Oyaji* may include responsibility for material supply, but is more often confined to the supply and management of labour. The terms of the contract are usually a fixed price for an item or package of work. The *Oyaji* mobilises the workers, manages their output and pays them on a daily basis until the work is finished. His reward is the difference between his costs and the contract sum. In this situation the *Oyaji* is acting as an entrepreneur, (or a true labour contractor) in that he is taking a risk and hoping to make a profit. He tries to maximise his profit by controlling his labour costs and other expenses and getting the best possible price from the subcontractor. In good times the profit can be almost double the wage of a skilled worker, but substantially less (or even a loss) in bad times [*ibid*].

Under the second alternative the contractor pays the *Oyaji* a monthly income for supplying the labour but retains the responsibility for managing the work. The *Oyaji* may be responsible for paying the workers or they may be paid directly by the contractor. The *Oyaji* is serving as a mobiliser of the required number of workers, as well as the leader of the group or gang. But he is not working as a labour contractor. The essential difference is that his reward comes in the form of a wage or a fee rather than a profit. The authors do not explain the circumstances in which this system is preferred. But it can be conjectured that it may be when contractors need to manage the labour force directly in order to control the quality of the work and/or if the *Oyaji* is inexperienced in the particular techniques that are adopted.

Labour Outsourcing in Nepal

A study of building labour in Nepal [Jha (2002)] provides further detail on the alternative forms of contract for the supply of labour. The intermediaries who supply labour in Nepal are known as *Naikeas*. The *Naikeas* mobilise and supply labour to construction clients, ranging from class A contractors to individual house owners. As in Korea, most *Naikeas* have a number of workers permanently attached to them. Participants usually come together through family or friends and form a socially cohesive group, ranging from 5 to 50 members. If additional labour is required, unskilled labourers may be picked up from the designated pick-up points in the towns, but they also may eventually become permanent members of the group and have a chance to acquire skills, albeit informally [*ibid*].

Because of their central role as suppliers of labour, *Naikeas* are often referred to as 'labour contractors'. However, the *Naikeas* sometimes do more than what would normally be expected of a labour contractor and sometimes they do less.

Instances where they do more can be found in the private house-building sub-sector. In Nepal it is estimated that 90% of private owners of residential or non-residential buildings do materials management by themselves. However, the *Naikea* may advise the client on materials, coordinate material supply, provide and manage tools and basic equipment, as well as assuming responsibility for general supervision. On larger building projects the client may assign responsibility for the entire construction to a gang headed by a *Naikea,* while still retaining materials management to him/herself. In this case the client would enter into a verbal agreement on the rates for various items of work, so payment would be on a task rate basis. Payments are made by the client to the Naikeas as each item is completed, minus a retention which is only paid after the completion of the work. The *Naikeas* were reported to pass on the retention to the labourers, who are usually employed on a daily basis. Both *Naikeas* and labourers complained of overdue payments by the client. Sometimes the money owing is never paid [*ibid*].

The arrangements can be very different from the above, with the *Naikea* undertaking far fewer tasks and less responsibility. For example, on infrastructure projects in rural areas, especially projects involving large quantities of earthworks, it is common for the *Naikea* to serve merely as a middleman, mobilising and leading a gang of unskilled workers but taking no responsibility for work supervision (or any other aspect of construction) unless specifically asked to do so. The research found that contractors and subcontractors have an extensive network of contact persons (*Naikeas*) in all parts of the country, some of whom are on their permanent payroll. There are two alternative forms of engagement. The first is where the contractor pays the labourers directly and pays a commission to the *Naikea* for mobilising the labourers. In such instances it is normal for the contractor to retain full and direct control over the workers. Alternatively, the *Naikea* may undertake to pay the labourers and take on some of the responsibility for their supervision. In this instance it is normal for him (there are no women working as *Naikeas*) to take, in addition to his own wage, a cut from the wages of the labourers. If he is paid on a task or piece rate basis, he has a direct incentive to complete the work in the allotted time. Even if his pay is not related to output he still has some incentive to perform well and complete the work to the contractor's satisfaction in order to win work from the contractor at some future date [*ibid*].

The organisation of building labour in Kenya

Similar patterns of recruitment of labour through intermediaries have recently been found in two separate studies in East Africa. A study of labour in the building sector in Nairobi (Kenya) revealed that the majority of buildings are now constructed using the '*informal construction system*', whereby the materials are provided by the building owner and no contractor is involved [Mitullah and Wachira (2003)]. The field research focused on the suburb of Kayole which is characterised by a large number of high rise low income residential developments. Interviews with 100 respondents working on 20 sites found that 80% of clients buy materials and supervise construction themselves. But in 17% of cases the client appointed a *foreman* to buy and manage materials and supervise the work on site on. Occasionally the *foreman* would also be authorised to hire workers but more generally, especially on small sites, workers would be hired directly by the client. In 14 of the 20 sites covered in the study the owners of the development were the employers of the workers on the site and 60% of the workers interviewed said they were hired and paid directly by the building owners [*ibid*].

However, even when labour is hired and paid directly by the client it is generally recruited through *gang leaders. Gang leaders* are usually artisans of many years experience, good reputations and good contacts with potential clients, who lead a group of skilled and unskilled men who usually work together. The gang leaders have the responsibility of getting jobs to keep the gang employed. They have control over their gangs and earn more than the gang members. The study found that most workers aspire to be *gang leaders* who are considered to be making more money. However the assumed benefits are not always realised because of the difficulty of finding work, particularly in hard economic times [*ibid*].

A minority (only 28%) of the workers interviewed said they were hired by *labour contractors.* The authors attempt to draw a distinction between *gang leaders* and *labour contractors*. Although it is not always clear cut, the distinction seems to be based on the payment arrangements and allocation of risk. A labour contractor would normally provide a lump-sum quotation for completing a particular task or item of work. On smaller projects this may be the complete building. The labour contractor would then recruit, supervise and pay all of the operatives required to complete the work. Operatives are usually paid daily on the basis of time worked, any difference between the lump sum labour payment to the subcontractor and the labour costs being the contractor's profit. A *gang leader* on the other hand would normally be responsible for mobilising workers and possibly for exercising some degree of supervision, for which he would receive a specific payment from the client. But he and the other labourers would still be paid directly by the building owner, hence limiting the amount of risk that he takes on. The gang leaders are essentially wage workers rather than entrepreneurs [*ibid*].

Informal workers in the construction industry in Tanzania

A two year 'Participatory Action Research' project undertaken by United Nations Volunteers (UNV) in collaboration with the ILO in Dar es Salaam (Tanzania) confirmed some of the findings from the Kenya study but also added other dimensions [Jason (2005)]. The project focused on 42 groups of construction workers, 31 of whom were supplying labour. The vast majority of labour suppliers indicated that the groups were formed for social security purposes and not for work or business development. The groups (which may have up to 100 members but more typically 8-30) accumulate funds from contributions which are then used to make payments to members when hit by adverse circumstances. Hence, the fact that workers are associated in groups does not necessarily mean that they always work together.

However, a few groups said they came together as a way of seeking 'identity', meaning recognition by clients and ability to promote their services. Some of them are specialised in particular trades, including one concrete gang, and in a number of groups members do work together for much of the time. While some (about a quarter of those interviewed) had sometimes worked for contractors, most find work with private clients who are building or repairing their houses using the *informal construction system.*

When hired as a group the person that gets the contract becomes the *gang leader* for the duration of the project. But the gang leader is not necessarily the leader of the group. Any member of the group may obtain an offer from a customer and bring others in the group to work with him [*ibid*[. Contracts are informal and payment may be by time, task or piecework depending on the preference of the client and the type of work. When a group of workers is recruited and payment is by task, the normal arrangement is for the *gang leader* to take the payment and share it among the group according to their contribution. The gang leader may get an additional payment from the client. But very few instances were found of a *gang leader* (or a group leader) acting as a *labour contractor* in the sense of negotiating a price with the client, employing the workers and making a profit or loss on the deal. Although labour contractors are known to exist in Tanzania and do undertake contracts for both private clients in the *informal system* and contractors in the formal construction industry [Mlinga and Wells (2002)] the groups of labourers in the project function more like worker cooperatives than small businesses. It is possible that the leaders of the groups, or any of the members who have good contacts with clients and a continuous flow of contracts, may eventually consolidate their position as *gang leaders*. They may also eventually accumulate sufficient capital to go on to develop into labour contractors. But at the present time these roles are embryonic.

CONCLUSION

A number of conclusions emerge from this brief review of recent research into the methods of recruitment of construction labour.

First, there is little doubt that ‘outsourcing’ is now the normal method of mobilising labour for construction projects throughout the developing world. The practice of engaging labour through intermediaries is well established and growing in a large number of countries.

Secondly, the research has revealed two basic patterns of labour engagement. In the first the contractor, subcontractor or client enters into a contract with an intermediary to mobilise, pay and supervise the number of workers required to complete a task. In the second the contractor, subcontractor or client engages an intermediary to mobilise the labour, while retaining the responsibility for their payment and their supervision. In the first case we have called the intermediary a *labour contractor* and in the second case a *gang leader.* The difference between the *labour contractor* and the *gang leader* lies in the work that they do, the method of payment and the allocation of risk. The *labour contractor* manages his workforce, takes on a large share of the risk involved in the work and if successful he is rewarded in the form of a profit. The *gang leader* works alongside the other members, takes little risk and is paid a wage or a fee. The first is an entrepreneur the second a wage labourer.

There are of course many variations in the detail of the arrangements and no hard and fast dividing line between the two alternatives. The particular form of engagement that is chosen by the contractor, subcontractor or client is a question for further research. It may be hypothesised that key variables influencing the decision might be the type of work to be carried out, in particular the level of technology and degree of complication in relation to the skill and experience of the workforce, as well as the level of development of the local industry. If the workforce or the labour contractors are inexperienced and/or the work complicated the contractor/ client might wish to retain more direct control.

The roles of *gang leader* and *labour contractor* are distinct. Although *labour contractors* may sometimes accept work as *gang leaders*, the reverse is unlikely as the labour contractor requires additional skills and capital. Both are well developed in the two Asian countries involved in the study. They are also evident, in the two studies in sub-Saharan Africa. However, amongst ‘informal construction workers’ in Dar es Salaam the position of *gang leader* is not yet consolidated and is distinct from that of leader of the group. Some group leaders may consolidate their position and become *gang leaders* or even *labour contractors* in time, but this opportunity is also open to any other member of the group and not just the group leader.

Finally, the research has indicated (although not fully demonstrated due to lack of space) the importance for construction workers of being associated with a group of workers. Association with a group provides the means to obtain work, acquire skills and some degree of social security and support. These factors are particularly important to those construction workers (often a majority) who are new migrants to the city from the countryside. The group also serves as a place for gaining experience and a seedbed from which future gang leaders and labour contractors might emerge. Programmes to improve skills, productivity or quality in the industry need to recognise this fact and engage with the labour contractors and the gang leaders as much as with the contractors.

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How Much Construction Should We Teach In Civil Engineering Programs?

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Abstract
This paper reviews the construction background of students that we are "formally" educating in Civil Engineering (CE) programs in Mexico. Curriculums at these programs have been too rigid, namely, a fixed set of courses for all students with just few electives. The most recent trend in those programs is to educate generalists, who may specialize later in a particular field of their choice, construction for instance. Most CE programs offer too many technical courses from the several areas comprising the civil engineering discipline. However, there is evidence that 70% of CE graduates will work in construction related jobs. Therefore, a question we need to address is, How to combine the needs for educating generalists and at the same time prepare them as future practitioners for the construction industry? It appears that today's CE programs are failing to provide proper education to the future construction actors, at least at the undergraduate level. What is the solution then? The author proposes in this paper a perspective that may allow a gradual learning process for those interested in pursuing a career in construction.

Keywords
Construction, education, civil engineering, construction education.

BACKGROUND

Most newcomers to the construction industry that we are "formally" educating in undergraduate programs come from traditional Civil Engineering or Architectural programs, and only a few from Construction Engineering programs. Engineering Technology programs in Mexico, unlike in developed countries, emerged recently and not offer construction related degrees yet. Table 1 shows undergraduate enrollment, students that completed their program, but have not yet graduated, and degrees awarded in those traditional programs during 2002 (ANUIES, 2003).

Table 1. Statistics of Construction Related Programs in 2002

Bachelor's Programs	Number of Programs		Undergraduate Enrollment		Completed Program		Degrees Awarded	
	Qty.	%	Qty.	%	Qty.	%	Qty.	%
Architectural	114	43.5	53,402	61.1	6,843	60.3	4,131	55.0
Civil	138	52.7	32,498	37.5	4,339	38.2	3,264	43.4
Construction	7	2.7	700	0.8	107	0.9	90	1.2
Other	3	1.1	529	0.6	56	0.5	29	0.4
Total	262	100.0	86,769	100.0	11,345	100.0	7,514	100.0

Even though the undergraduate programs of the fields listed above have characteristics in common, the author will focus now only upon Civil Engineering (CE) programs.

Most CE curriculums have been too rigid, meaning that all students enrolled had to take the same compulsory courses, and only a few elective ones. The majority of those programs have been course-oriented, offered on a semester basis. Even though most of those programs have converted or are converting their curriculums to credit-based systems, they are primarily administered on a semester fashion. On the other side of the spectrum, a small group of programs is too flexible, allowing students to take as many electives as possible once they covered the core courses. This practice leads in some instances to have students with strong preparation in their area of preference but forfeiting other areas offered within the program.

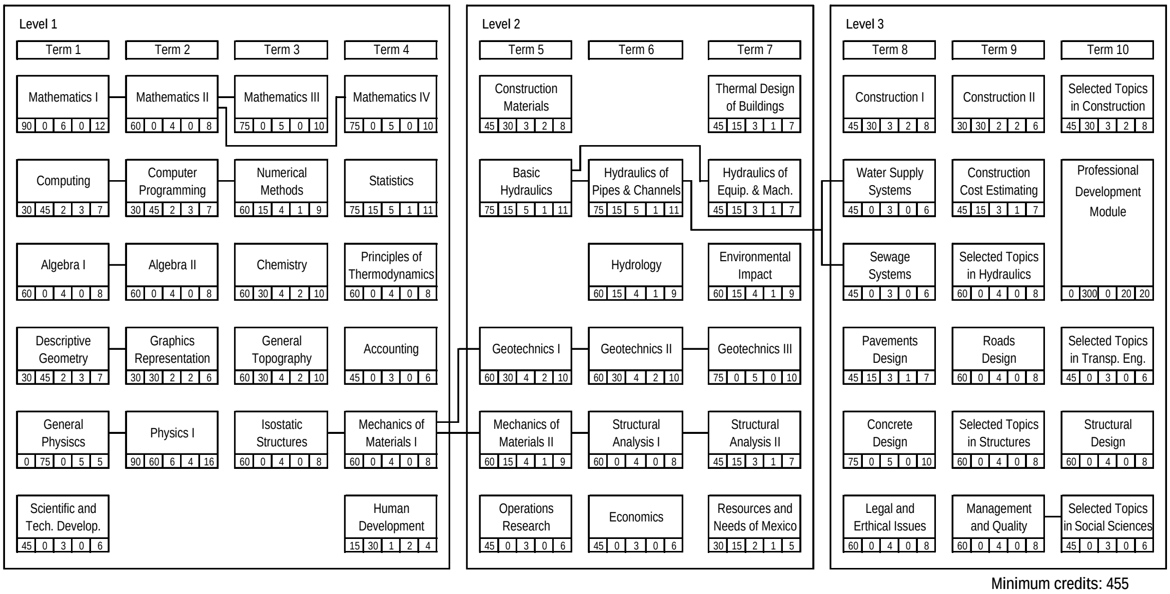
Two major organizations in Mexico[1] strongly recommend that education in all undergraduate engineering programs should be generalist, and Civil Engineering is not the exception. Both ANFEI and CACEI encourage that new professionals should be generalists first, and later on specialize in their area of interest, preferably after a couple of years of practical experience. However, statistics for the past 20 years from ANFEI show that about 70% of the newcomers from civil engineering programs get a job either directly or indirectly related to the construction sector.

A TYPICAL CIVIL ENGINEERING CURRICULUM

As a response to those recommendations the School of Engineering at the Universidad Autónoma de Yucatán (UADY - University of Yucatan) developed the curriculum shown in Figure 1. This CE curriculum, approved and started in 1996, is a 10-semester program, five and half courses per semester on the average, 15 weeks per semester, 25 lecture/lab hours per week, and all courses lectured by the program's own Faculty. Such curriculum, considered a pioneer at its time, is no longer followed at UADY, however is similar to most CE programs actually operating in Mexico. Therefore, it will be considered as reference framework for analysis.

Figure 1. UADY's 1996 CE Curriculum

[1] ANFEI – Asociación Nacional de Escuelas y Facultades de Ingeniería – National Association of Faculty and Schools of Engineering). CACEI – Consejo de Acreditación de la Enseñanza de la Ingeniería, A.C. (Accreditation Council for Engineering Education).



First, let us take a close look upon the specialized CE courses offered at Levels I, II and III, Basic Sciences, Engineering Sciences and Applied Engineering respectively, as defined by CACEI. These are grouped in four major civil engineering areas: Hydraulics, Geotechnics, Structures, and Construction. Table 2 shows the number of courses and credits for each major area.

Table 2. Distribution of Specialized Courses and Credits in a CE Curriculum

Major CE Area	Courses		Credits		Total 455 Credits
	Qty.	%	Qty.	%	%
Hydraulics	8	27.6	67	28.2	14.7
Geotechnics	7	24.1	61	25.6	13.4
Structures	8	27.6	66	27.7	14.5
Construction	6	20.7	44	18.5	9.7
Total	29	100.0	238	100.0	52.3

Then, it becomes evident the unbalance among those four major areas, particularly credits wise. The difference in courses does not look significant, however the number of credits allocated to construction courses is only 68%, on average, when compared to the other three major areas. Moreover, we should keep in mind that about seventy percent of those students will incorporate into the construction industry.

Second, let us ask the following: Who is teaching those construction courses? Civil Engineering is among the most practical of the engineering disciplines, and construction is even more practical. Therefore, experienced faculty should teach those few courses offered. Then, are we really doing so? In this regard, we should recall Peter Drucker's words: "the only way to learn a techné is through apprenticeship and experience."... "A techné can not be explained in words, whether spoken or written. It can only be demonstrated by one who had mastered it," where techné is the Greek word for skill, or ability to do. It will be interesting to conduct a research project to identify the profile of the "average" construction professor, not just in Mexico but worldwide.

Third, we are working under the premise that current CE programs have been designed to provide quality rather than quantity education to our students. Certainly, this premise applies not just for construction courses but also for all other fields taught in the program. Then, we should ask ourselves are we really doing that?

Fourth, we need to consider the ambivalent world where the construction sector is operating nowadays. It is an industry that is rapidly becoming multidisciplinary, multinational, and economically multibillionaire. It also involves large numbers of participants working concurrently at different locations and using heterogeneous technologies. A great deal of effort has been spent to be more effective and efficient, particularly during the past couple of decades. State-of-the-art information technologies have also been incorporated in their daily activities. Furthermore, construction professionals are more aware of the impact that projects they build have upon the environment, and they are more competitive from a business point of view as well. In this regard, are all these important issues, factors, parameters, and achievements part of those construction courses content, and, more importantly, taught and discussed in class?

Fifth, we also need to consider the structure and the organization of the construction industry. For instance in Mexico, CMIC (Cámara Mexicana de la Industria de la Construcción – Mexican Chamber for the Construction Industry) reports that 93% of the firms are classified as either micro or small (CMIC, 2004). That figure is equivalent to the 90% of the so-called small firms in United States, firms ranging from the self-employed entrepreneurs to organizations housing 15-20 employees. The same firms that will host a large majority of the 70% of the professionals mentioned above, looking for a job in the construction industry, and that will heavily rely on managerial duties to guarantee their survival in a very competitive environment. Are those few management related courses enough to prepare them to face their future managerial responsibilities?

What is the solution to those issues then? Can we combine the needs to educate civil engineers as generalists and at the same time prepare them to perform well in the construction industry? The approach followed at UADY's School of Engineering to address these questions is presented next.

RESTRUCTURING A CIVIL ENGINEERING CURRICULUM

A major review of the 1996 CE curriculum was conducted during several months, resulting in a new program approved in July 2003 and started the following month. Among the requirements established by the Administration stand out the following: 1) Continue the generalist approach, as recommended by ANFEI and CACEI, 2) balance both the course and credit loads between the major four areas included in the curriculum, 3) reduce the total number of credits to complete the degree, 4) reduce the number of weekly hours per semester.

Faculty from each of those major areas gathered in teams and reviewed their own their share of the program. In all instances, their first proposals resulted in more courses, more lecture hours per week, and more credits than in the 1996 UADY's CE curriculum. The general from faculty claim was that more knowledge is generated every day, requiring a larger "space" to teach it. On the average, one and a half extra courses per area were deemed necessary by them, increasing the academic load to 28 hours weekly, and the total number of credits close to 500. Then, the administration suggested a different strategy; namely, identify the minimum body of knowledge required in each basic area, not just the four mentioned, to become a generalist civil engineer. This new exercise resulted in the curriculum shown in Figure 2. The restructuring of course for the four major civil engineering areas is also shown in Table 3.

The reader should be aware that a student could take other elective courses, four on the average. This could result in an addition of up to 25 credits (6 % of the total required to complete the program) if he or she concentrates in one of the four major areas mentioned above.

Figure 2. UADY's 2003 CE Curriculum

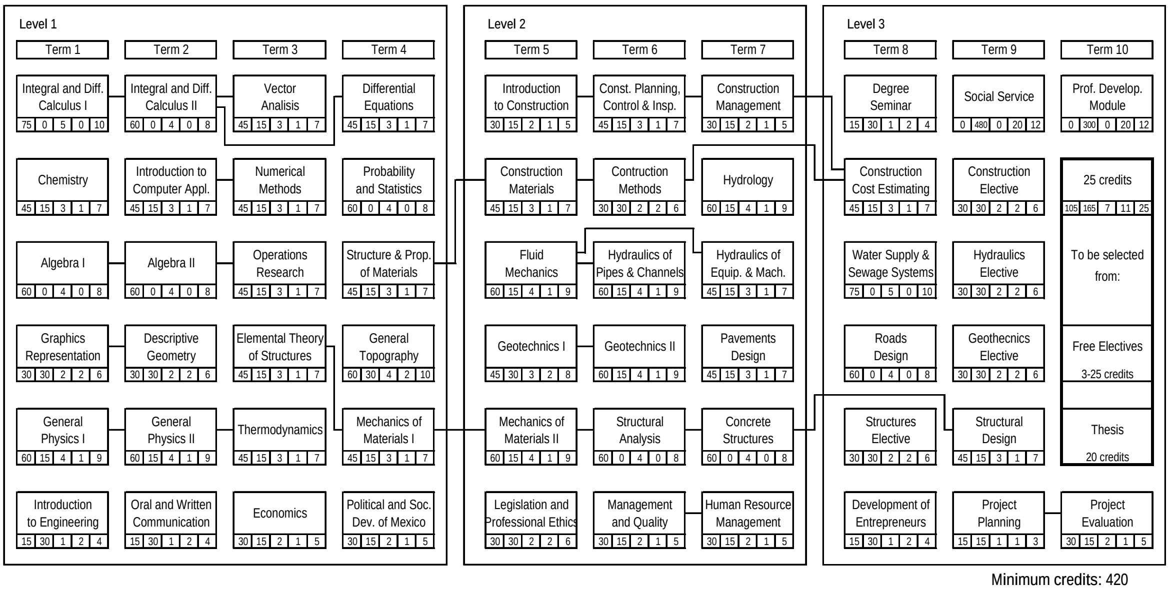


Table 3. New Distribution of Specialized Courses and Credits in a CE Curriculum

Major CE Area	Courses		Credits		Total 420 Credits
	Qty.	%	Qty.	%	%
Hydraulics	6	23.1	50	25.9	11.9
Geotechnics	6	23.1	48	24.9	11.4
Structures	7	26.9	52	26.9	12.4
Construction	7	26.9	43	22.3	10.2
Total	26	100.0	193	100.0	46.0

The restructuring resulted in a comparable workload for the four major areas. However, the most important goal achieved was the definition of the body of knowledge deemed as "minimum necessary" in each area to fulfill the requirement to provide a general education while at the same time fulfill the specific demand from students and employers. For example, six compulsory courses include, comprehensively, everything that is required to address the three approaches that construction practice demands: 1) technology, 2) management, and 3) information systems. All other areas were treated similarly.

This strategy helped to fulfill the first two requirements posed by the Administration: continue the generalist approach and balancing of the course and credit loads between the major four areas included in the curriculum. Regarding reducing the total number of credits to complete the degree and the number of weekly hours per semester this was partially accomplished since the reductions were not significant. Instead of 455, a student requires only 420 credits in the new program, a 7.7% reduction. The weekly course load was reduced from 25 to 23.5 hours, a 6.0% reduction.

The issues upon who should be teaching the courses, providing quality rather than quantity knowledge, and addressing the specific needs from the construction sector, points 2, 3, and 4 in the previous section, were solved with a bold strategy: delegate these responsibilities to the faculty appointed to the Construction Engineering and Management (CEM) graduate program. UADY's CEM graduate program was established in 1981 and integrated with a large and experienced faculty body; including leaders in their own areas of expertise, with a good mix of theoretical and practical experience.

The philosophy at UADY's CEM has been that education in construction should provide a solid foundation in three key areas: 1) Technology, 2) Management, and 3) Information Systems. Technology, as the roots of construction, rose to its highest level. Management as the basis to deal with the most valuable of the resources that construction leaders will face, the human resource. Information Systems taught to be used as the great tool they are, primarily to solve problems with the support of current computational technology. Furthermore, a compulsory coop program was included in the program so students could obtain a minimum of experience/practice during one semester.

Regarding management knowledge, the pertinence of teaching only two management courses in the program was reviewed, particularly that a good number of future civil engineers will be taking care of their own construction business. Several authors present bold statements about the managerial functions that today's professionals need to perform. For instance, Webber (1993) stated, "managers have to attract and motivate the best people; reward, recognize, and retain, train, educate, and improve them – and, in the most remarkable reversal of all, serve and satisfy them." Knowledge and skills that can hardly be transmitted less practiced in a couple of isolated courses. Webber also praises that in a knowledge economy, managers should consider *work as conversation*. This is a skill far away to be acquired in the too technically oriented engineering programs.

In the same line of thought, Hout and Carter (1995) declare, "process-focused companies (such as construction firms) need more top-down management, not less." Therefore, the new program includes courses such as Communication, Management of Human Resources, Development of Entrepreneurs, Planning and Project Evaluation, besides the ones offered before, all of them taught by practitioners well known in their areas of expertise.

CONCLUSIONS

It appears that today's CE programs are failing to provide proper education to the future construction actors, at least at the undergraduate level. Furthermore, they are not designed to train civil engineers to face roles as construction leaders, particularly in the management arena. The new educational paradigm establishes that civil engineers should be prepared as generalists, however there is strong evidence that 70% graduates will incorporate into construction related jobs. Therefore, a question demanding a proper answer is How to combine the needs to educate generalists and at the same time prepare them as future construction practitioners?

The first step should be to keep undergraduate education in civil engineering programs, as it is now, generalist. Then, we have to provide a flexible education to satisfy everyone's personal interest, not just in construction but also in any other field. Therefore, it should be a balanced number of courses in construction technology and management to guarantee a minimum level of knowledge in those areas at least. Furthermore, a minimum of experience/practice should be acquired at this level through compulsory coop programs. We demand internship for future physicians. Why engineering/construction, or any other profession, should be different? Are owners, clients, and users willing to take unnecessary risk, such as a poorly constructed facility?

The next step should be to acquire real life experience working in construction firms. Perhaps a minimum of two years is required, or as much as needed. After this, professionals will be ready for the final stage in their formal educational process, graduate school.

The new CE curriculum designed at the University of Yucatan attempts to address the requirements discussed above. Though the first class from this new program will not graduate until June 2007, partial results are very promising. Both students and faculty have expressed their satisfaction upon the construction courses already taught.

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An Educational Initiative to Address Earth Systems Engineering for Developing Communities

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Abstract
Developing economies are facing unprecedented demands for water, food, waste disposal, health care, energy, land, materials, environmental cleanup, and infrastructure. Population growth could be as high as two billion in the next two decades and 95% of the growth is expected to take place in developing or under-developed countries. The role of engineers and constructors will be critical in fulfilling those demands. In response to the global nature of the problems that Earth is facing, the Department of Civil, Environmental, and Architectural Engineering at the University of Colorado has started an initiative called Earth Systems Engineering. As a subset of Earth Systems Engineering, the Department is proposing to implement an "Engineering for Developing Communities" theme in the Civil and Environmental degrees at the University of Colorado. The mission is to educate globally responsible students who can offer sustainable and appropriate technology solutions to the endemic problems faced by developing communities worldwide. This paper will discuss the initiative with a focus on the tasks that are being pursued in the undergraduate construction engineering and management curriculum.

Keywords
Engineering education, engineering curriculum, sustainability, appropriate technology.

BACKGROUND

Introduction

The worldwide population is expected to grow by almost two billion people in the next two decades and 95% of that growth will likely take place in developing or under-developed countries. This will create unprecedented demands for water, food, waste disposal, health care, energy, land, materials, environmental cleanup, and infrastructure. Civil engineers will play a vital role in creating the infrastructure to fill these demands. However, most existing engineering curricula fail to expose young engineers to the wide array of social, environmental, economic, cultural, and ethical aspects that are needed to address such issues [National Academy of Engineering (2004)]. A worldwide transition to a more holistic approach to engineering education is required. Engineers must incorporate a systems perspective and embrace the principles of sustainable development, renewable resources management, appropriate technology [Hazeltine et al. (1999)], natural capitalism [Hawken et al. (1999)], biomimicry [Benyus (1997)], and biosoma [Bugliarello (2000)]. Further, there is a need to recruit engineers from the entire population in order to meet these demands. In response to these needs, The University of Colorado is modifying its Bachelor of Science degrees in Civil Engineering and Environmental Engineering. The University is attempting to emphasize these important aspects of engineering education through a diverse range of pedagogical tools.

The purpose of this paper is to present several evolving initiatives in the Department of Civil, Environmental and Architectural Engineering at The University of Colorado and provide a focus on the pedagogical tools that are being incorporated into classes in the Construction Engineering and Management Program. Specifically, this paper will discuss:

- Earth Systems Engineering
- Engineering for Developing Communities
- Construction Engineering and Management Initiatives

Earth Systems Engineering

In response to the global nature of the problems that Earth is facing, The University of Colorado has started an initiative called Earth Systems Engineering (http://ese.colorado.edu). The initiative emphasizes the role of civil, environmental and architectural engineering in society and the interaction between the built environment and natural and cultural systems. Earth Systems Engineering encompasses the concepts of sustainability and Green Engineering [National Science Foundation (2003)]. Allenby introduced the concept of Earth Systems Engineering with reference to industrial ecology which is defined as "the multidisciplinary study of industrial systems and economic activities, and their links to fundamental natural systems". [Allenby (1999)] The U.S. National Academy of Engineering defines Earth Systems Engineering as [National Academy of Engineering (2000)]:

> *"A multidisciplinary (engineering, science, social science, and governance) process of solution development that takes a holistic view of natural and human system interactions. The goal of Earth Systems Engineering is to better understand complex, nonlinear systems of global importance and to develop the tools necessary to implement that understanding."*

A 3-day workshop on Earth Systems Engineering was sponsored by the National Science Foundation and conducted at The University of Colorado in 2001 (http://ese.colorado.edu/workshop.htm). The 90 workshop participants from industry, government, and academia encompassed the fields of engineering and physical, biological, and social sciences and unanimously proposed the following definition: "*The engineer of the future applies scientific analysis and holistic synthesis to develop sustainable solutions that integrate social, environmental, cultural, and economic systems.*" These ideas are also encompassed by the National Academy of Engineering's report, The Engineer of 2020 [National Academy of Engineering (2004)]: "*Engineers will continue to be leaders in the movement toward use of wise, informed, and economical sustainable development.*" The University's Earth Systems Engineering initiative involves engineering education, research and development, and outreach and practice. Earth

Systems Engineering embraces the principles of sustainability, appropriate technology, industrial ecology, renewable resources, natural step and natural capitalism, biomimicry, and systems thinking. The Earth Systems Engineering initiative has also been selected as one of five major initiatives in the College of Engineering & Applied Science at The University of Colorado.

The University of Colorado Civil Engineering program has several educational objectives (as required for Accreditation Board for Engineering and Technology 2000) that embrace Earth Systems Engineering concepts (http://bechtel.colorado.edu/Abet/ce_objectives.html). For instance, *Bachelor of Science graduates in the Civil Engineering program will be able to:*

- *Understand how non-technical concerns such as cost, public safety and health influence civil engineering projects.*
- *Uphold ethical relationships with both clients and the public at large.*
- *Understand broad social and cultural issues so they can participate fully in a democratic society.*

However, these ideas have not yet been broadly implemented across the curriculum. In the exit survey given to the 24 spring and summer 2004 Civil Engineering graduates to evaluate educational outcomes, the only area of concern (with an average score below 3.75 on a scale of 1 to 5) was "the ability to understand how non-technical concerns influence Civil Engineering." Exit interview results from the 11 fall 2004 Civil Engineering graduates indicated two areas of concern, one being "understanding the broad social issues so that they can participate in a fully democratic society." The tasks described later in this paper will allow us to implement Earth Systems Engineering concepts into the undergraduate engineering curricula in Civil and Environmental Engineering.

Engineering For Developing Communities Program

As a subset of Earth Systems Engineering, the University of Colorado is implementing an "*Engineering for Developing Communities*" theme in the Civil Engineering and Environmental Engineering degrees (http://www.edc-cu.org). The mission is to educate globally responsible students who can offer sustainable and appropriate technology solutions to the endemic problems faced by developing communities worldwide. Such global problems are not usually addressed in engineering curricula in the U.S., leaving most engineers unprepared to address the needs of the most destitute people on our planet, many of them living in industrialized countries. This is unfortunate as it is estimated that 20% of the world's population lack clean water, 40% lack adequate sanitation, and 20% lack adequate housing [World Bank (2003)]. Engineers also have a critical role to play in helping the ~1.8 billion people (30% of the world's population) living in conflict zones, in transition, or in situations of permanent instability resulting from political conflicts, famine, land shortage, or natural hazards [World Bank (2003)]. The Engineering for Developing Communities program will serve as a blueprint for the education of engineers of the 21st century who have:

- the skills and tools appropriate to address the critical issues that our planet is facing;
- an awareness of the needs of the developing world; and
- an ability to contribute to the relief of the endemic problems of povertyThe Engineering for Developing Communities program is being developed in partnership with groups including: (1) universities, technical, and vocational schools in the US and abroad; (2) engineering companies;

(3) humanitarian organizations; (4) non-governmental organizations; and (5) interested individuals. The program is designed to address a wide range of issues such as water provisioning and purification, sanitation, health, power production, shelter, site planning, infrastructure, food production and distribution, communication, and jobs and capital for various developing communities including villages, refugee settlements, etc. Our program is a step toward fulfilling the aspirations of the National Academy of Engineering:

> "*a future where engineers are prepared to adapt to changes in global forces and trends and to ethically assist the world in creating a balance in the standard of living for developing and developed countries alike.*"[National Academy of Engineering (2004)]

The Engineering for Developing Communities program is currently in its development and implementation phases. A graduate program in Engineering for Developing Communities as a special track in the Masters of Science/Doctor of Philosophy program in Environmental Engineering at The University of Colorado started in spring 2004. The next goal is to offer an Engineering for Developing Communities curriculum option to undergraduate students. An interest survey was distributed to graduate students in environmental engineering and students in the undergraduate capstone Environmental Engineering Design course, with 20 of the 25 survey respondents indicating yes or maybe that they would have enrolled in an Engineering for Developing Communities track in a Bachelor of Science degree in Environmental or Civil Engineering, if available.

The Engineering for Developing Communities program at The University of Colorado joins a number of programs around the world that offer university students community service, an exposure to international development and sustainability, and hands-on international experience as part of their education. A review of these programs can be found at (http://www.edc-cu.org/about-programs.htm). The uniqueness of our program is that it includes three interactive and synergistic components, namely *education, outreach and service,* and *research and development*.

CURRICULUM DEVELOPMENT AND INTEGRATION

Goals and Objectives

The overall goal of our proposed program is to educate engineers to integrate social, environmental and sustainable principles into their decision making. Earnestly and actively pursuing this goal will:

- Attract and retain the brightest students including women and minorities to civil and environmental engineering;
- Better educate engineering students to meet the 21st century needs of both developed and developing domestic and international communities; and
- Create a community of engineering educators devoted to improved training of future engineers.

The approach of the education component of the Earth Systems Engineering and Engineering for Developing Communities programs is to develop and implement new courses and modify existing courses to emphasize issues critical to the understanding of the social impacts of engineering and critical needs in the developing world. The curriculum changes encompass three areas: (i) incorporation of Earth Systems Engineering concepts throughout the Civil Engineering Bachelor of Science degree; (ii) addition of a new Engineering for Developing Communities emphasis in Civil Engineering; and (iii) addition of a new Engineering for Developing Communities option within the cross-departmental Environmental Engineering Bachelor of Science degree. Students across the College of Engineering will have the opportunity to participate in a certificate program in Engineering for Developing Communities and an Earth Systems Engineering theme will thread through the new honors program. Each of these elements is described in more detail below.

Curriculum Integration

An effective method of teaching engineers to integrate sustainability and human and natural factors in their engineering work is to thread Earth Systems Engineering concepts throughout the undergraduate curriculum. By teaching Earth Systems Engineering concepts throughout the entire 4-year degree, students will have the opportunity to continually build on a foundation of knowledge and integrate the concepts into their complete engineering education. Specific courses throughout the Civil Engineering curriculum will be identified for incorporation of Earth Systems Engineering and/or Engineering for Developing Communities concepts. As desired by the Accreditation Board of Engineering and Technology in their outcome assessment criterion, should be able to "understand the impact of engineering solutions in a global and societal context." Courses in which Earth Systems Engineering concepts are already emphasized or new modules are being considered include:

- Year 1: Introduction to Civil Engineering (1 credit); Engineering Geology;
- Year 2: Thermodynamics; Environmental Engineering Fundamentals;
- Year 3: Introduction to Construction; Construction Equipments and Methods; Probability and Statistics; Hydraulic Engineering; Geotechnical Engineering I and/or II; and
- Year 4: Senior Seminar (1 credit); Engineering Economy & System Design.

For a full description of these courses, please refer to (http://ceae.colorado.edu).

Integration into Construction Engineering and Management Courses

The University of Colorado's undergraduate Construction Engineering and Management curriculum is a traditional blend of engineering, management, and professional practice courses. Since sustainability and environmentally conscious design and construction issues have not been traditionally taught in construction courses or found in the texts currently being used in the program, current courses primarily focus mainly on productivity issues and technologies that are not appropriate for developing communities. However, recent research and advances in the construction profession have produced excellent opportunities to expose students to the Earth Systems Engineering and Engineering for Developing Communities themes within modules of almost all the courses. Additionally, construction courses offer opportunities to employ active pedagogical approaches to learning though implementation of these learning modules. The current Construction Engineering and Management classes available to undergraduate students at the University of Colorado are:

- Year 3 Core Requirements: Introduction to Construction, and Construction Equipment and Methods; and

- Year 4 Technical Electives: Introduction to Building Construction, Construction Contracts, Cost Engineering, Planning and Scheduling, and Project Administration.

As part of the overall curriculum reform, the Construction Engineering and Management program is initially proposing to implement and Earth Systems Engineering and Engineering for Developing Communities modules in the year 3 core construction requirements. In this manner, all of the Civil and Environmental Engineering students will be exposed to the initiative.

Introduction to Construction is a third-year core requirement for all Civil and Environmental Engineering students. The course provides an overview of Construction Engineering and Management. It summarizes the nature and environment of the construction industry and practice through an exploration of specific concepts and issues involved in contracts, project delivery, project planning, scheduling, cost estimating, and project controls. It introduces procurement, value engineering, quality assurance, and safety and health in construction. Team projects and in-class exercises are designed to complement the topics covered in the lectures. The purpose of the in-class exercises is to provide the students with a hands-on framework for understanding construction engineering and management.

Introduction to Construction provides and excellent opportunity to add a module on environmental conscious construction that supports the Earth Systems Engineering thrust. The faculty will develop a module that focuses on the economic, socio-political, and environmental implications involved with construction engineering and management decision making. Specifically, the module will focus on two concepts in the Earth Systems Engineering theme: *industrial ecology* and *zero emissions*. Industrial ecology emphasizes the role of material flow and waste flow. Industrial ecology offers a blueprint for rethinking how we can use materials and energy more efficiently. By emphasizing manufacturing construction byproducts so that they become raw materials for new processes reduces pollution. The net result is to try to prevent waste as much as possible and reduce any impact to the natural environment. Zero emissions represents a shift in our concept of industry away from linear models in which wastes are considered the norm, to integrated systems in which everything has its use. It heralds the start of the next industrial revolution in which industry mimics nature's sustainable cycles and humanity, rather than expecting the earth to produce more, learns to do more with what the earth produces. The module will discuss these concepts and provide students with the opportunity to design a construction operation that incorporates them. The students will be asked to design temporary construction operations that involve waste, such as concrete formwork design, temporary bridge falsework, and temporary earth retaining structures that best meet the ideals of industrial ecology and zero emissions.

Construction Equipment and Methods is also a third-year core requirement for all Civil and Environmental Engineering students. The course investigates the principle concepts, tools and techniques for construction engineering, equipment, and methods. It provides an integrated study of engineering economics, construction equipment and construction methods. Specific topics include the time value of money, equipment costs, equipment productivity, equipment selection and construction engineering design including concrete formwork, falsework, and temporary construction.

Construction Equipment and Methods provides and excellent opportunity to add a construction engineering design module that emphasizes the Engineering for Developing Communities through the use of *appropriate technologies*. Appropriate technology, as defined by the United State Congress's Office of Technology Assessment, is technology that is small scale, energy efficient,

environmentally sound, labor intensive, and controlled by the local community. A central concept of appropriate technology is that the technology must match both the user and the need in complexity and scale. Students will be asked to design a solution to a construction engineering problem using appropriate technology that can be used in developing communities, rather than in the United States. Perhaps the greatest impact the students can have is on the *safety of construction operations* in developing communities, therefore the designs will focus on worker safety during construction. For example, students will be asked to design temporary bracing with appropriate technology for residential structures built from earth or adobe bricks. Another example will be to design appropriate safety measures for fall protection in hand-dug well construction. The construction engineering and management community has made extraordinary advance in worker safety in the United State in the past 30 years. The students will apply this knowledge to design safer working conditions in developing communities by focusing on appropriate solutions with materials that are locally available and applicable to the local work force.
Introduction to Building Construction is a third-year requirement for construction students in the Architectural Engineering part of the department and a fourth-year technical elective for civil engineering construction students. The course addresses the introduction of fundamental building materials for students including their production, their use in design and construction, and the relative costs and benefits associated with each material.

The Introduction to Building Construction course will provide an excellent backdrop for students to learn the environmental cost of building materials in different parts of the world. For example, the environmental costs of concrete versus steel, or the cost of old-forest logging for timber can be integrated into the existing curriculum to illustrate the impact of materials in both developed and developing communities. This illustration will expand traditional introductions to materials by providing students with a complete picture of material costs versus the traditional perspective of final cost data.

Evaluation and Assessment

The curriculum integration being discussed is admittedly in its formative stages and the evaluation is not yet complete. However, the University is proposing to evaluate the curriculum integration thoroughly. Findings from this thorough formative evaluation will both enhance the success of the project goals, as well as identify and document the social dynamics that contribute to and/or inhibit the project outcomes. Key evaluation/research questions are:

- How does this project influence students' awareness of and responses to global needs, including service-oriented aspects of work in their career aspirations?
- How does this project influence the recruitment and retention of both women and males from under-represented groups into engineering generally and this project specifically?
- How do specific aspects of the pedagogy and curriculum employed in this project affect project success? For example, how do they influence student attitudes?

The proposed evaluation-with-research design incorporates a series of ethnographic interviews and includes ongoing testing of insights as they emerge. Insights gained from early interviews are explored further in subsequent interviews; therefore, protocols are fluid, rather than static, in nature. Interviews are minimally structured from the beginning so as to encourage interviewees to reveal their own perspectives instead of tailoring their input in response to categories introduced by researchers. The evaluation/ research team will meet frequently to discuss their observations from interviews and collectively refine the protocols to draw on emergent findings. These methods of data collection and analysis are ethnographic, rooted in methodological traditions common to sociology, anthropology and social psychology, and in the theoretical work of the phenomenologists [Schutz (1970)] and symbolic interactionists [Berger et al. (1966) Blumer (1969) Hughes (1971)].

CONCLUSION

The curriculum changes in Environmental and Civil Engineering represent a systemic and fundamental change in the education of future engineers and constructors. The 21st century presents new challenges to both the developed and developing worlds. A new body of knowledge is required for engineers to be adequately prepared to meet these challenges. It is no longer acceptable for civil and environmental engineers to leave a university with an education that focuses primarily on the demands of the local highway or wastewater treatment plant. Rather, it is time for the next generation of engineers to have the knowledge, experience, and sensitivity that prepares them to meet both the challenges of enhancing the infrastructure within the United States as well as meeting the basic needs of the international community. The initiatives in at the University of Colorado and specifically in the Construction Engineering and Management classes provide engineers with this unique perspective by embracing Earth Systems Engineering concepts and creating programs in Engineering for Developing Communities within the constructs of a civil or environmental engineering degree. It unites the strengths and skills of a group of committed faculty to advance the common goal of introducing a new concept of engineering education. It provides the foundation for introducing a common thread of knowledge throughout the engineering curriculum that is built up from the freshman year through senior design. It provides higher visibility to a profession that is called to play a critical role in creating structures and technology needed to sustain the quality of life of current and future generations. Finally, it will establish the curriculum model for educating engineers of the 21st century to play a critical role in contributing to peace and security in an increasingly challenged world.

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Ergonomics in Construction: South African Perspective

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Abstract
Construction is by its very nature a problem in ergonomics requiring work above head height and below waist level. Construction materials are necessarily heavy, and by virtue of shape and / or form, may not engender lifting and handling. Furthermore, a range of design, procurement and construction interventions impact on ergonomics, which reflects the need for multi-stakeholder contributions thereto.

The paper reports on findings emanating from a range of previous surveys reported on in literature and a recent study conducted among delegates attending a series of seminars.

Salient findings include: bending and twisting, and repetitive movements predominate among ergonomic problems encountered; structure (structural steel), installation of services (structure), and structure (reinforced concrete) predominate in terms of the impact of stages of projects on ergonomics; standard of site housekeeping and contractor awareness, predominate in terms of the extent to which aspects negatively affect ergonomics safe working procedures, constructability, and awareness predominate in terms of the extent aspects could contribute to an improvement in ergonomics.

The findings amplify the need for a multi-stakeholder approach to construction ergonomics.

Keywords
Construction, ergonomics, benefits, multi-stakeholder

LITERATURE SURVEY

Introduction

According to La Dou (1994) ergonomics, derived from the Greek ergon, 'to work', and nomos, 'study of', is literally the study of work, or the work system, including the worker, his or her tools, and his or her workplace. He states that "it is an applied science concerned with people's characteristics that need to be considered in designing and arranging things that they use in order that people and things will interact most effectively and safely."

Schneider and Susi (1994) maintain construction, by its very nature, is a problem in ergonomics as it requires work above shoulder level and below knee height. Materials may also be heavy and /or inconveniently sized and shaped, thus presenting manual materials-handing problems. Gibbons and Hecker (1999) emphasise that numerous construction tasks pose significant ergonomic risks to workers.

Given the abovementioned and the opportunity presented by a national series of Construction Ergonomics seminars, a survey was conducted to determine the perceptions of multi–stakeholder delegates. The study reported on in this paper constitutes part of a continuous study directed towards investigating the role and impact of construction ergonomics in / on the construction process, related practices and influences, the objectives of this phase being to determine the:

- frequency at which ergonomics problems are encountered;
- impact of various stages of a project on construction ergonomics;
- extent to which various design, procurement and construction related aspects negatively effect construction ergonomics, and
- extent to which various design and construction aspects could contribute to an improvement in construction ergonomics.

Nature of ergonomic problems

Based upon a score out of 10, research conducted among six trades in the USA determined the following to be the top five ergonomic problems: working in the same position for long periods (5.67); bending or twisting the back in an awkward way (5.46); working in awkward or cramped positions (5.00); working when injured or hurt (4.69), and handling heavy materials or equipment (4.63) (Zimmerman, Cook and Rosecrance, 1997).

Previous research conducted in South Africa investigated, inter alia, the frequency at which ergonomic problems were encountered (Smallwood, 1997; Smallwood, Deacon and Venter, 2000; Smallwood, 2002). The problems are ranked in Table 1 based upon an importance index (II) with a minimum value of 0, and

Table 1: Frequency of ergonomic problems encountered in construction according to management and workers (adapted from Smallwood, 1997*; Smallwood, Deacon and Venter, 2000**; Smallwood, 2002) (II = 0-4).

Problem	GC*		Worker*		Worker**		BP GC***		Mean	
	II	Rank	II	Rank	II	Rank	II	Rank	II	Rank
Repetitive movements	3.29	1	3.56	1	2.97	3	3.78	1	3.40	1
Climbing and descending	2.88	2	3.01	4	3.23	1	3.56	2	3.17	2
Handling heavy materials	2.63	4=	2.68	10=	3.00	2	3.44	3	2.94	3
Use of body force	2.80	3	2.82	8	2.77	5	3.00	9	2.85	4
Exposure to noise	2.53	7	2.93	6	2.65	6	3.11	6=	2.81	5
Bending or twisting the back	1.96	11	3.47	2	2.38	7	3.22	4=	2.76	6
Reaching overhead	2.61	6	2.99	5	2.00	13	3.11	6=	2.68	7
Reaching away from the body	2.41	8	3.19	3	2.03	12	2.63	12	2.57	8
Working in awkward positions	1.70	12	2.85	7	2.30	9	3.22	4=	2.52	9
Handling heavy equipment	2.03	10	2.17	13	2.87	4	2.78	10	2.46	10
Working in hot conditions	2.29	9	2.68	10=	2.15	10	2.33	13	2.36	11
Vibrating tools and equipment	2.63	4=	1.43	16	1.96	14	3.11	6=	2.28	12
Working in cramped positions	1.46	15	2.48	12	2.13	11	2.67	11	2.19	13
Staying in the same position for long periods	1.29	17	2.76	9	2.30	8	2.11	14	2.12	14
Working in humid conditions	1.60	13	1.53	15	1.66	17	1.89	15	1.67	15
Working in cold conditions	1.38	16	1.80	14	1.85	15	1.22	17	1.56	16

Working in wet conditions	1.57	14	1.21	17	1.70	16	1.67	16	1.54	17
Working while injured or hurt	0.19	18	0.84	18	0.48	18	0.44	18	0.49	18

a maximum value of 4, which in turn was based upon management and worker responses to a frequency range. It is notable that handling heavy materials, which achieved a ranking of fourth in South Africa, achieved a ranking of fifth in the USA. Although the other respective top four ranked problems were not common to both South Africa and the USA, bending or twisting the back, which achieved a ranking of second in the USA, achieved a ranking of sixth in South Africa.

Trade related ergonomic problems and design remedies

Schneider and Susi (1994) reviewed the findings of a team of industrial hygienists who followed the construction of a four-storey office building for the 15-month duration of the project. Relative to trades, the following examples are a summary and provide an indication of the ergonomic hazards which result from the construction process and possible design and construction related solutions.

Concreting: Shoveling and smoothing the surface of concrete is strenuous on the lower back. The addition of plasticisers improves concrete workability.

Reinforcing: The fixing and tying of bar reinforcing requires bending and a great deal of rapid repetitive twisting of the wrist, the latter resulting in the development of ganglion cysts. The use of fabric in lieu of bar reinforcing reduces the amount of time spent fixing and tying reinforcing per concrete element, and the amount of bending and rapid repetitive twisting of the wrist. Using trestles also enables steel fixers to fix cages at ‘worktop’ level.

Formwork: The erection and striking of support work and formwork requires a large amount of bending, twisting and body force. Designers can facilitate the use of composite systems through the simplification of design, among other, table forms and wall forms which can be handled by cranage, thereby reducing the manual content of an activity. The use of precast concrete also reduces the amount of support work and formwork and on-site fixing and tying of reinforcing required. Prestressed concrete elements, particularly slabs, also reduce the amount of bar reinforcing.

Structural steelwork: Ergonomic problems relating to the erection thereof include awkward postures, occasional high force requirements, static postures, repetitive movements, use of pneumatic tools and lifting. The high risk nature of the activity which entails, inter alia, straddling beams several feet in the air while aligning and bolting together columns and beams, compounds the problems. Preassembly, simplified joints and integral safety features can reduce the hazards.

Masonry: Block and brick laying represents major ergonomic hazards to workers. Lifting an average of 1 000 bricks a day is the equivalent to lifting 2 300 – 4 000kg, and 1 000 trunk-twist flexions. A Construction related intervention includes the provision of waist high materials platforms. Design improvements include the incorporation of hand holds in blocks to facilitate lifting. Alternative wall systems constitute the optimum solution.

Roofing: Roofing poses many different ergonomic hazards, but primarily materials handling. Of the three types of roofing, unit and sheet materials and waterproofing membranes, unit materials require considerably more bending, twisting and handling of mass per square metre of covered area, than sheet materials. The use of ‘ladder type’ tile lifts facilitates the lifting of unit materials to roof level.

Building fabric: Differing systems and materials pose differing ergonomic problems. Concrete surface finishes such as bush-hammering present a risk of hand-arm vibration and health problems such as silicosis. Natural stone claddings require a lot of lifting and hoisting of panels, adopting of awkward postures and hand-arm vibration as a result of fixing, presenting a risk of back injury and hand/wrist problems. Design alternatives include light weight sheet metal claddings and curtain walling.

Plumbing and drainage/pipefitting: Piping is often at odd angles and in cramped spaces. Specific piping materials have specific jointing methods, not all of which are complementary to ergonomics. A number of installations are suspended and require extensive overhead work, the fixing of the suspension hangers resulting in substantial stretching and twisting and consequently a high level of stress on the neck and shoulders of workers. Designers should consider the ergonomic implications of jointing methods when specifying materials, the feasibility of prefabricated stacks, and horizontal and vertical service ducts for piping.

Electrical: Electricians often work in cramped postures and their work entails a large amount of wrist action resulting in stress on the arm and shoulders. Making connections requires extensive use of hand tools, often in cramped spaces such as ceilings above and between ducting and other piping. Designers should make adequate provision for access during both design, and coordination of services during design.

Floor finishes: All floor finishes require constant kneeling and bending. Ceramic and similar tile and terrazzo work entail additional risk. Often the weight of the tiles to be set can be substantial, particularly if natural stone. Terrazzo and similar finishes require considerable hand and wrist motion. When specifying finishes designers should consider the nature of processes pertaining thereto. Using trestle type work benches reduces the need for tilers to cut at floor level.

Suspended ceilings: Most suspended ceilings require significant overhead work although the components are not particularly heavy. It is necessary to suspend primary tracks from hangers and secondary tracks between the primary tracks. Screw-up suspended ceilings require considerably more overhead work than lay-in tile ceilings. Consequently designers should specify the latter where possible. The use of mobile tower scaffolds with full work platforms are more complementary to ergonomics than the use of ladders.

Painting and decorating: Overhead painting of ceilings places considerable stress on the arms and shoulders, as well as the neck. Designers should consider self-finishes where possible.

Paving and other external work: Brick paving requires work similar to that of tiling. In addition, pavers often have to be cut with an electrically powered masonry saw which requires working at ground level, and consequently bending. The use of work bench type masonry saws does reduce the ergonomic hazard. Although asphalt paving exposes workers to whole-body and hand-arm vibration, workers are not exposed to the volume of repetitive movements and other work related postures as in the case of brick paving.

Impact of various stages of projects on construction ergonomics

Previous research conducted in South Africa investigated the impact of ten stages on construction ergonomics (Smallwood, 2002). Eight of the ten stages were deemed have more a major than a minor impact: structure (structural steel); structure (reinforced concrete); roof; cladding / external fabric; installation of services (structure); ceilings; walling / partitions, and external works. Finishes; site clearance and earthworks were deemed to have more a minor than a major impact.

Aspects which impact on construction ergonomics

Previous research conducted in South Africa investigated the extent to which various design, procurement and construction aspects impact on construction ergonomics. Nine of ten aspects were deemed to have more of a major than a minor impact: standard of site house keeping; amount of work relative to project duration; format of materials; general design; degree of contractor awareness relative to ergonomics; details; specification; degree of contractor planning, and degree of mechanisation. Type of procurement system was deemed to have more of a minor impact – between a near minor impact to impact / impact.

Improving construction ergonomics

Previous research conducted in South Africa also investigated the extent to which various design and construction related interventions could contribute to an improvement in construction ergonomics (Smallwood, 2002). Thirteen aspects were deemed to be able to contribute to an improvement: awareness; constructability (general); safe working procedures; general design; design of equipment (construction); mechanisation; reengineering; details; contractor planning; design of tools; prefabrication; workshops on site, and specification. Furthermore, five of the thirteen aspects were deemed to have between near major to major / major potential to contribute.

RESEARCH

Sample frame and methodology

The sample stratum consisted of 38 delegates attending a series of four ergonomics seminars. 34 Delegates responded, which constitutes a response rate of 90%. The survey questionnaires were circulated prior to the commencement of the seminar modules to avert the possibility of influence arising from the delivery thereof.

Findings

Table 2 indicates the frequency at which ergonomics problems are encountered in terms of percentage responses to a range 'never' to daily, and because the range consists of five-point scale, in terms of a mean score ranging between 1 and 5. It is notable that seventeen of the eighteen problems have mean scores above the midpoint score of 3.00, as this indicates that the problems can be deemed to be generally encountered. Furthermore, it is significant that the top ten ranked problems are identical to the mean top ten problems identified in four previous studies, albeit the rankings are not alike (Smallwood, 1997; Smallwood, Deacon and Venter, 2000; Smallwood, 2002).

Furthermore, those problems with mean scores:

- > 4.20 ≤ 5.00, namely the top six ranked, can be deemed to be encountered between daily to weekly and daily / daily;
- > 3.40 ≤ 4.20, namely those ranked seventh to fourteenth, can be deemed to be encountered between weekly to fortnightly and daily to weekly / daily to weekly;
- > 2.60 ≤ 3.40, namely those ranked fifteenth to seventeenth, can be deemed to be encountered between fortnightly to monthly and weekly to fortnightly / weekly to fortnightly; and
- > 1.80 ≤ 2.60, namely working while hurt or injured, can be deemed to be encountered between never to fortnightly to monthly and fortnightly to monthly;

Table 2: Frequency of ergonomic problems encountered in construction.

Problem	Response (%)						II	Rank
	Unsure	**Never**	**Fort-nightly to monthly**	**Weekly to fort-nightly**	**Daily to weekly**	**Daily**		
Bending or twisting the back	2.9	0.0	2.9	0.0	23.5	70.6	4.67	1
Repetitive movements	2.9	0.0	2.9	5.9	20.6	67.6	4.58	2
Working in awkward positions	2.9	0.0	2.9	5.9	50.0	38.2	4.27	3
Reaching away from the body	0.0	2.9	2.9	8.8	35.3	50.0	4.26	4
Handling heavy materials	0.0	2.9	2.9	8.8	41.2	44.1	4.21	5=
Climbing and descending	0.0	0.0	6.1	12.1	36.4	45.5	4.21	5=
Exposure to noise	0.0	0.0	9.4	9.4	34.4	46.9	4.19	7
Reaching overhead	0.0	2.9	5.9	5.9	41.2	44.1	4.18	8
Use of body force	2.9	0.0	2.9	14.7	44.1	35.3	4.15	9
Handling heavy equipment	2.9	2.9	2.9	11.8	50.0	29.4	4.03	10
Staying in the same position for long periods	2.9	5.9	8.8	8.8	35.3	38.2	3.94	11
Working in cramped positions	0.0	2.9	8.8	17.6	52.9	17.6	3.74	12
Working in hot conditions	12.1	0.0	15.2	21.2	30.3	21.2	3.66	13
Vibrating tools and equipment	0.0	8.8	8.8	32.4	29.4	20.6	3.44	14
Working in cold conditions	15.2	0.0	27.3	15.2	30.3	12.1	3.32	15
Working in humid conditions	12.1	6.1	24.2	21.2	30.3	6.1	3.07	16
Working in wet conditions	14.7	0.0	29.4	29.4	20.6	5.9	3.03	17
Working while hurt or injured	23.5	29.4	20.6	5.9	11.8	8.8	2.35	18

Table 3 indicates the extent to which the various stages of projects impact on construction ergonomics in terms of percentage responses to a scale of 1 (Minor) to 5 (Major), and a mean score ranging between 1 and 5. It is notable that all the stages have mean scores above the midpoint score of 3.00, as this indicates that the stages can be deemed to generally impact on construction ergonomics. However, given that the mean scores for the top two ranked stages are > 4.20 ≤ 5.00, the stages can be deemed to have between a near major to major / major impact. It should be noted that the third ranked structure (reinforced concrete) has a mean score marginally below the cut point. The remaining stages, those ranked third to tenth have mean scores > 3.40 ≤ 4.20, and thus can be deemed to have an impact to near major / near major impact on construction ergonomics.

Table 3: Extent of impact of the various stages of a project on construction ergonomics.

Stage	Response (%)						II	Rank
	Unsure	Minor…………………………………… Major						
		1	2	3	4	5		
Structure (Structural steel)	5.9	2.9	2.9	11.8	26.5	50.0	4.25	1
Installation of services (Structure)	2.9	0.0	0.0	14.7	47.1	35.3	4.21	2
Structure (Reinforced concrete)	5.9	2.9	2.9	11.8	32.4	44.1	4.19	3
Ceilings	2.9	5.9	5.9	11.8	26.5	47.1	4.06	4
Cladding / External fabric	8.8	5.9	5.9	11.8	29.4	38.2	3.97	5=
Roof	8.8	8.8	2.9	5.9	38.2	35.3	3.97	5=
External works	2.9	2.9	5.9	23.5	35.3	29.4	3.85	7
Finishes	3.0	9.1	9.1	18.2	27.3	33.3	3.69	8
Site clearance and earthworks	0.0	6.1	9.1	30.3	27.3	27.3	3.61	9
Walling / Partitions	2.9	5.9	5.9	32.4	35.3	17.6	3.55	10

Table 4 indicates the extent to which various aspects impact on construction ergonomics in terms of percentage responses to a scale of 1 (Minor) to 5 (Major), and a mean score ranging between 1 and 5. It is notable that with the exception of type of procurement system, the mean scores of all the aspects are above the midpoint score of 3.00, which indicates that the aspects can be deemed to generally impact on construction ergonomics. However, given that the mean scores for the top two ranked aspects are > 4.20 ≤ 5.00, the aspects can be deemed to have between a near major to major / major impact. It is notable that both aspects are contractor related. Those aspects ranked third to ninth have mean scores > 3.40 ≤ 4.20, and thus can be deemed to have an impact to near major / near major impact on construction ergonomics – degree of contractor planning is totally contractor related and degree of mechanization is partially contractor related. Format of materials is manufacturer related, and amount of work relative to project duration is client and principal agent related. Details, specification, and general design are design related. Last ranked type of procurement system, which can be deemed to have between a near minor impact to impact / impact, is client and designer related.

Table 4: Extent to which aspects negatively affect construction ergonomics.

Aspect	Response (%)						II	Rank
	Unsure	Minor……………………………… Major						
		1	2	3	4	5		
Standard of site house keeping	3.0	3.0	3.0	6.1	33.3	51.5	4.31	1
Degree of contractor awareness relative to ergonomics	6.1	3.0	6.1	9.1	21.2	54.5	4.26	2
Degree of contractor planning	6.1	3.0	3.0	15.2	30.3	42.4	4.13	3
Degree of mechanisation	3.0	3.0	6.1	18.2	27.3	42.4	4.03	4
Format of materials	6.1	3.0	9.1	21.2	18.2	42.4	3.94	5
Amount of work relative to project duration	3.0	6.1	6.1	21.2	21.2	42.4	3.91	6
Details	6.1	6.1	3.0	36.4	21.2	27.3	3.65	7
Specification	6.1	9.1	6.1	21.2	33.3	24.2	3.61	8
General design	3.0	6.1	12.1	24.2	30.3	24.2	3.56	9
Type of procurement system	3.0	15.2	12.1	24.2	24.2	21.2	3.25	10

Table 5 indicates the extent to which aspects could contribute to an improvement in construction ergonomics in terms of percentage responses to a scale of 1 (Minor) to 5 (Major), and a mean score ranging between 1 and 5. It is significant that the mean scores of all the aspects are above the midpoint score of 3.00, which indicates that the aspects can be deemed to generally have the potential to contribute to an improvement in construction ergonomics. Furthermore, it is significant that ten of the twelve aspects have mean scores > 4.20 ≤ 5.00, which indicates the aspects can be deemed to have between near major to major / major potential to contribute to an improvement in construction ergonomics. Eleventh ranked reengineering has a mean score marginally below the cut point, and along with specification and details can be deemed to have between potential to near major / near major potential to contribute to an improvement in construction ergonomics.

Table 5: Extent to which aspects could contribute to an improvement in construction ergonomics.

Aspect	Response (%)						II	Rank
	Unsure	Minor………………………………. Major						
		1	2	3	4	5		
Contractor planning	0.0	0.0	0.0	12.1	21.2	66.7	4.55	1=
Safe working procedures	0.0	0.0	0.0	12.1	21.2	66.7	4.55	1=
Constructability (general)	3.0	0.0	0.0	9.1	27.3	60.6	4.53	3
Awareness	0.0	0.0	0.0	9.1	30.3	60.6	4.52	4
Mechanisation	0.0	0.0	0.0	12.1	30.3	57.6	4.45	5
Workshops on site	0.0	0.0	0.0	12.1	33.3	54.5	4.42	6
Prefabrication	3.0	0.0	3.0	21.2	15.2	57.6	4.31	7
Design of equipment (construction)	0.0	3.0	0.0	12.1	33.3	51.5	4.30	8
Design of tools	0.0	6.1	0.0	12.1	24.2	57.6	4.27	9
General design	3.0	3.0	3.0	6.1	42.4	42.4	4.22	10
Reengineering	3.0	0.0	0.0	15.2	48.5	33.3	4.19	11
Specification	3.0	6.1	0.0	12.1	39.4	39.4	4.09	12
Details	3.0	6.1	3.0	9.1	42.4	36.4	4.03	13

CONCLUSIONS

A range of ergonomic problems can be deemed to be consistently encountered in South African construction. The findings of previous research reported on in the review of the literature and those emanating from the research reported on in the paper lead to this conclusion. This is further reinforced by the research finding that the top ten ranked out of eighteen problems are identical to the mean top ten problems identified in four previous studies, albeit the rankings are not alike. This conclusion amplifies the need for all stakeholders to consider inter alia, the implications of a design, specification, and proposed method of work.

Ergonomics is impacted upon by all stages of a project. Structure (structural steel) and structure (reinforced concrete) are still ranked within the top three. However, installation of services (structure) is ranked higher, namely second. In general it can be concluded that the impact of all stages of projects on ergonomics has remained consistent.

A range of aspects can be deemed to consistently negatively affect construction ergonomics – design, procurement and construction included. Furthermore, a range of aspects could contribute to an improvement in ergonomics. These conclusions reinforce the need for a multi-stakeholder approach to construction ergonomics.

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Chilean Experience on Constructing Job Skills Evaluation

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Abstract
About 6 years ago, government organizations and the most important and representative institution from Chilean Construction Sector began to study a project to set up a national skills certification system. Home Electrician, Home Gas Fitter and Gas Assistant Inspector Skills evaluation and certification were selected for the first stage. A fully government financed first stage called *Programa Piloto Cero Falta* (No Mistake Program). This Program was realized with some Chilean universities cooperation.

Near 350 construction workers participated on a gas and electricity job skills evaluation process carried out by Technological Metropolitan University of Chile. Some aspects and characteristics are analized. Some results obtained were: a) 60% from registered candidates became accredited workers; b) Candidates with all job skills approved were between 30 to 40 years old and had high school certificate; c) Workers with few studies could not approve initial tests; d) 90% of candidates required training. Suggestions and recommendations for evaluations process improvement are proposed.

Keywords
Skills, evaluation results, gas, electricity.

INTRODUCTION

Job evaluation is a system to measure the relative demands of different jobs in an organization in order to determine their relative place in a job hierarchy. A job evaluation scheme covering all groups of staff in an institution or in a production sector provides employers with an effective defence against claims for equal pays. So, job evaluation system gives the possibility to evaluate candidates who want to enter to the organization by means of a set of tests to measure their skills and knowledge for the job. Furthermore, workers who received a formal education can get official job skills acknowledge. In addition, the job description must be done under the headings given by all the people implicated on a production sector, such as employers, professionals and technicians, educators, government and, in this case, construction training representatives.

During the past 6 years, various Chilean representative institutions carried out an iniciative to evaluate and certificate construction job skills or competencies. These initiatives were developed in the following areas: tourism; gastronomy; construction, computation and great mining.
In the construction area, a process was developed to evaluate home-electricians, gas assistant inspectors and home-gas fitters, because of accidents occurred where some people died. This first process, called "No Mistakes Program" was conducted for 4 institutions: SENCE (National Training and Employ Service); Fundación Chile (Chile Foundation); SEC (Electricity and Combustibles Superintendency) and Corporación de Capacitación de la Construcción de la Cámara Chilena de la Construcción (Construction Training Corporation from the Chilean Construction Association). Candidate evaluations were fully financed in this Program.

Our university participated in this process as an evaluation institution for these skills. In the following pages, we present the process, results and some proposals for the next future.

OBJECTIVES

The present paper has the following objectives:

a) some considerations about job skills and construction job skills carried out in Chile are discussed;
b) more than 200 workers gas & electricity job skills are analized during evaluation process at Technological Metropolitan University (UTEM) at Santiago; and
c) age, worker type, educational level and evaluation results are compared.

Some considerations about construction job skills

Since some years ago, diverse initiatives have been generated in many developed and developing countries in the scope of education so that technical and professional formation aims that students learning for satisfying and developing productive sector demands. Like this, ending profiles are expressed as competencies. For example, the Chartered Institute of Building, CIOB, (1) with the development of the Professional Development Program, made an explicit effort to identify those skills or competencies it required for individuals to become full chartered members of the body. Accordingly to this, what can we understand for skills or competencies?

Chile Foundation says (2), "with slight differences, it tends to agree that competencies are those visible behaviors, skills and attitudes of people that contribute to a specific activity scope in an effective and satisfactory way. Competencies or skills allow to connect people's theoretical knowledge ("To know") with some skill practices ("To do"), transformig them into "Knowledge to do". White Book of the European Union (3) defines it as "An individual capacity to realize tasks and operations set and norms or quality standards regulation principles". Whence Guy Le Boterf (4) states, "Competency is not a determined knowledge, ability and attitude set that exists and that people can have or not, but it is something constructed as results from determined situation performing requirements".

Whatever, a skill or competency meaning could be "capacity for doing a productive function at any context, accordingly to productive sector quality requirements".

Accordingly to Minister of Education of Chile (5) there exist at least 4 processes by means of which it is possible to apply job skill concept. These are:

- *Competencies identification*: work qualitative analysis process to define knowledge, ability and practice skills involved when a worker performs effectively his job function.
- *Evaluation by job skills*: verification process of performances evidences compared with a standard previously validated. Evaluation results are a judgement founded on the available evidences upon a worker is competent or not.
- *Job skill certification*: formal recognition process of worker competency previously evaluated against explicit requirements contained on current competencies regulations. Certification must be made by an independent institution to assure a clear and legitimate process.
- *Formation focused upon competencies*: teaching ad learning process which contributes to develop knowledge and abilities and generates practice skills and moreover, promotes capacities to apply and move them to real working situations allowing then to develop their competencies in different contexts and new situations.

At Spain, INEM (Institute of Employment) (6) has developed an action set and working lines to train and certificate job skills. It means that education and training has been structured upon specific job competencies to provide an effective and good job performance. In the case of Pais Vasco (7) it is possible to obtain a technical title by means of job skill certification.

Therefore, evaluation is a process by means job performance evidences are collected to determine if an individual is "competent" to carry out a determined work function. There are different methods to do that, such as: ability tests; duty observation; simulation and situational exercises; written test; verbal asks and alternatives questionnaires.

CHILEAN PROCESS DESCRIPTIONS

On March 1999, skills job system started as it is described further on. The first stage consisted in work competencies standard definition for worker key areas. This definition was made by productive world representatives.

The second stage was Gas, Electricity and Gastronomy Trial Project which started in 2001 and was denominated Programa Cero Falta (No Mistake Program). For this purpose, SECE gave special resources in order to evaluate workers who fulfilled the following characteristics: large work experience; low officials califications; few opportunities for work or professional development. Workers benefits were: work skills evaluation; special training focused on work skills development; work skills certification.

SENCE had full supervision and responsibility of the process, but they delegated on Chile Foundation for designing, evaluating, certificating and quality assessment for beneficiaries service. Chile Foundation selected specials institutions as evaluators. The evaluating institutions received work skills training in order they could work homogeneously. Gremial productivity organization was the institution encharged of certification. For Gas and Electricity the responsible was the Chilean Construction Association and various universities were the evaluating institutions.

When No Mistake Program ended, the third step came up that consisted on National Work Skills Certification System installation.

NO MISTAKE PROGRAM EXPERIENCE AT UTEM

Start process

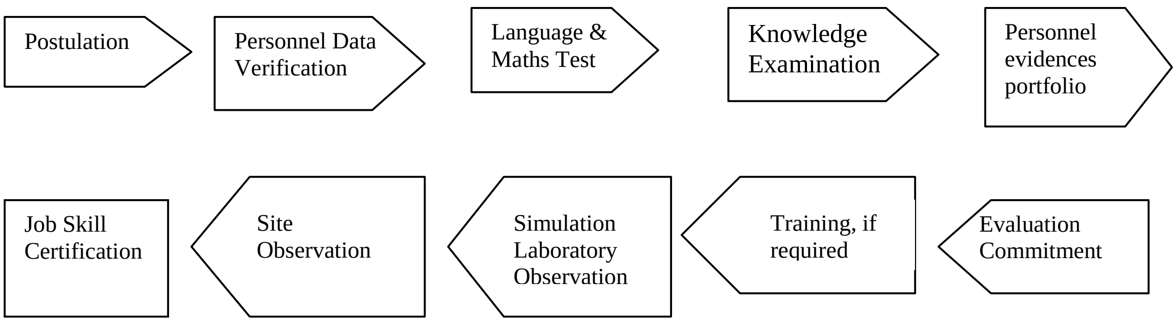
UTEM was invited by Chile Foundation in August 2001 as an evaluating institution for the gas and electricity work skills. Cooperation Agreement between both institutions was signed in 2001 and on December 2001 the process started.

UTEM agreement stated that 200 gas and electricity workers should be evaluated within the process. Our estimation was that UTEM needed at least 50% more candidates to obtain the 200 certificated gas and electricity workers.

Characteristics process

A lineal process was designed because of the postulant goes on step by step. Figure 1 shows flowing chart process.

Figure 1: Flowing chart process

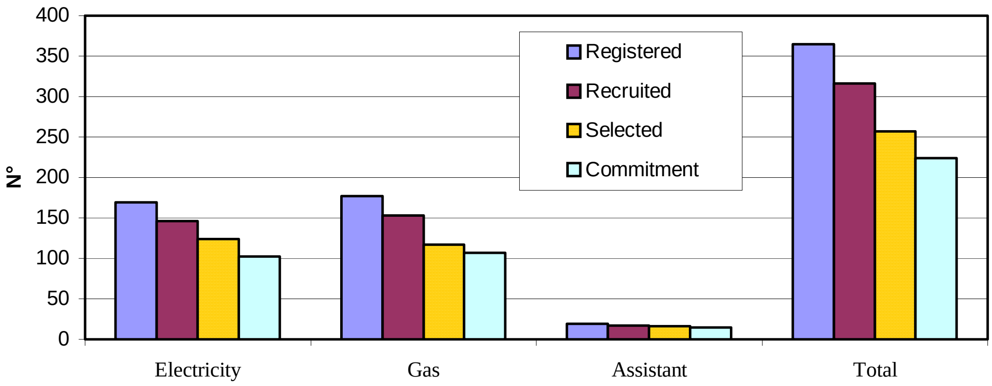


Each worker interested in his skills certification gave us his personnel data, wich were analyzed by us. As selection method a Language & Mathematics Test was applied to candidates who were between 20 to 50 years old, with at least one year of work experience and basic school certificate. Time process followed with a Knowledge Examination about theoretical concepts and technical regulations aspects. The workers, who approved both tests, could deliver their personnel work evidences. Evaluation Commitment was signed only by approved candidates. Evaluation Commitment defined which job skill units would be evaluated by means of simulation laboratory and on site observation. When candidates did not reach some job skill unit should go to a training period. There were two types of job skill units: obligatory and optional. Numbers of each one were different for gas and electric areas: three obligatory and one optional for electric skills; two obligatory and one optional for gas skills; and two obligatory and one optional for gas assistant inspector.

Results process at UTEM

Over 650 workers were interested in this evaluation process. About 350 candidates were registered at UTEM. 316 of them satisfied the requirements and after the first test 257 were selected. Finally after the second test, only 224 workers signed his Evaluation Commitment. Chart N°1 shows process evolution by distribution areas.
Greater difference between gas and electric postulants were presented during this period. That is, a large number of electrical recruited postulants than gas postulants completed their data. The main reason of this was that postulants from gas area had more difficulties in fulfilling the expected requirements and in getting evidences of their previous jobs.

CHART Nº 1: Evolution process by distribution areas



Only 216 fulfilled the whole process. Chart Nº2 shows the kind of work these postulants had.

CHART Nº2: Kind of work of postulants

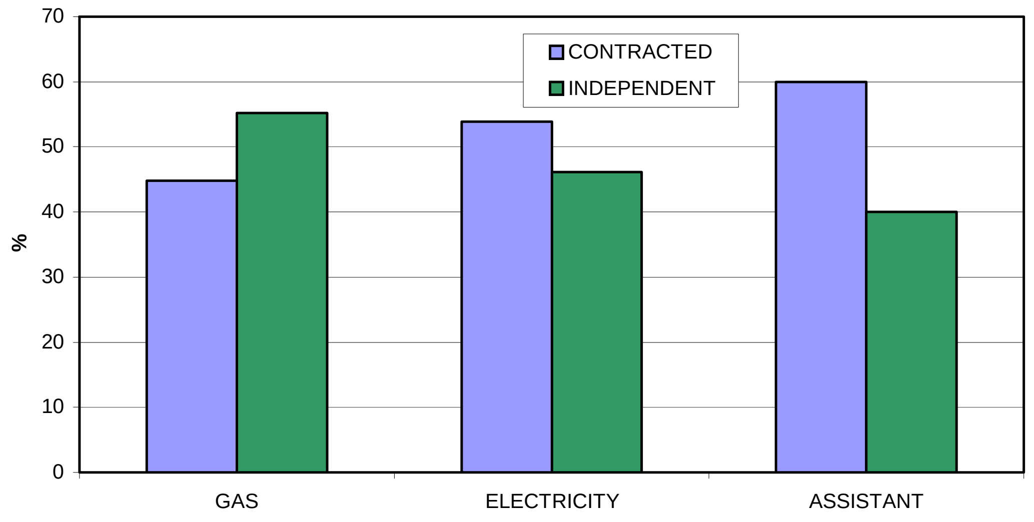


Chart N°3 shows the candidates educational level by job skills areas. Chart N°4 shows the relationship between candidate age and job skills results.

Graphic Nº3 Candidates educational level by job skills areas

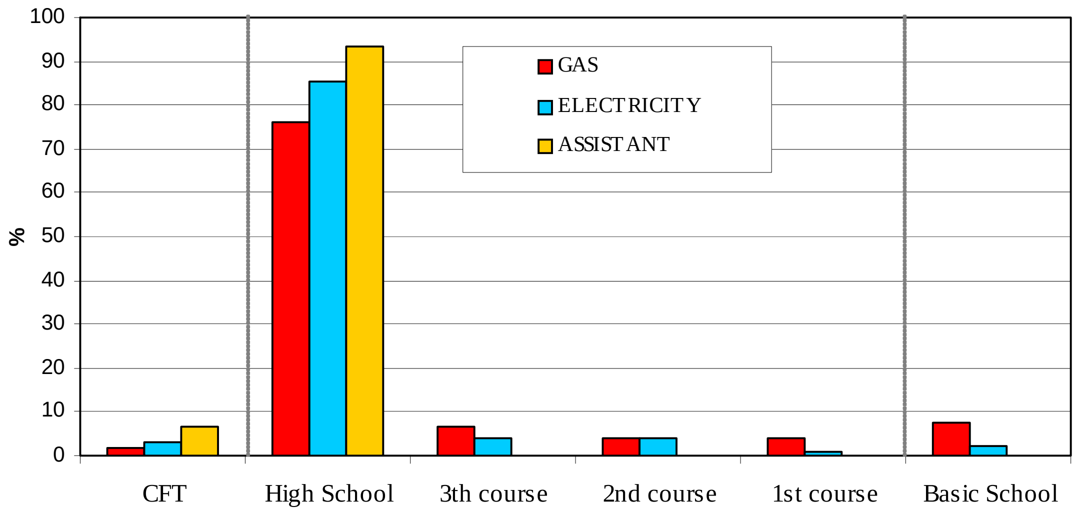
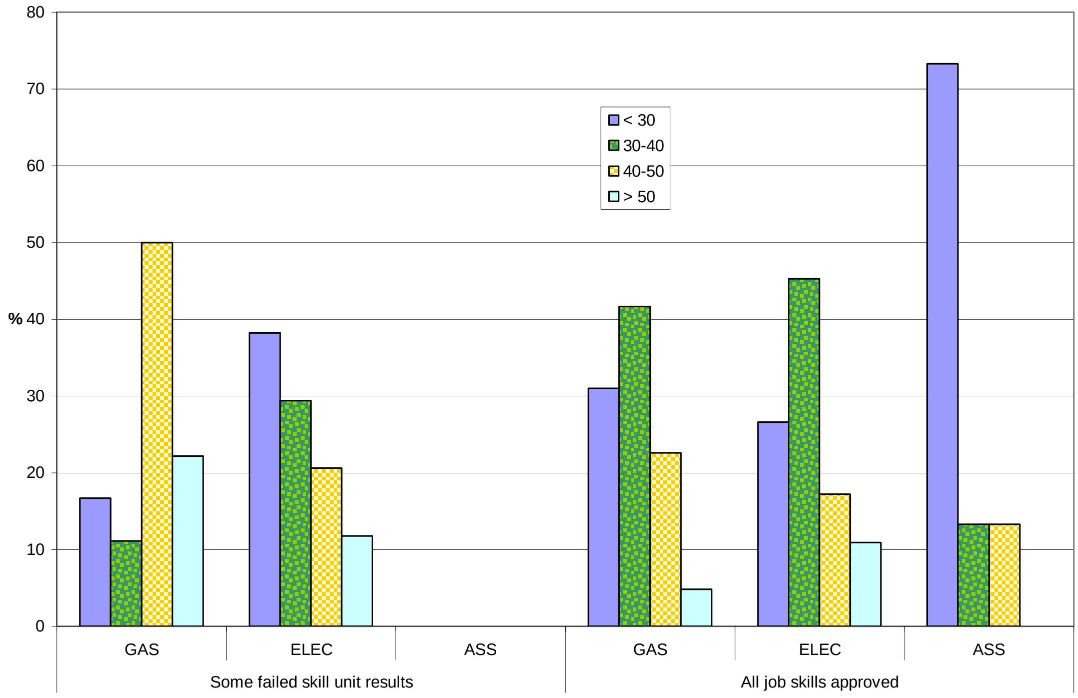


Chart Nº4: Candidate age vs. job skills results



CONCLUSIONS AND COMMENTARIES

Conclusions

Our hypothesis was true. It stated that we needed at least 300 postulants to obtain 200 candidates with their job skills approved. From 357 registered postulants we got 216 accredited workers. Number of candidates were similar in both gas and electricity area.

Candidates with all job skills approved were between 30 to 40 years old and had high school certificate. Independent workers under 30 years old and few experienced years reproved one job skill unit. Candidates over 40 years old reproved preferably one obligatory job skill unit. Although the program was designed for people under 50 years old, it was necessary to justify the presence of some people over this age due to their experience and results in the two tests previous to the Evaluation Commitment signature.

Educational level practically had no influence because workers with few studies could not approve Language & Maths and Knowledge Tests.

A great number of candidates (90%) had to take a training period causing the process took longer time and a second evaluation of those skills not approved the first time.

The success of the Assistant Gas Inspector in the evaluation process is due to all candidates proceeded from a previous special training course. Because of this, it is important to state that there were no postulants over 50 years old and all of them approved their competencies with no difficulties.

Commentaries

There was a significative number of "mapuche" people among the electrical postulants. It is also relevant to state that only one woman participated in the process that approved as Assistant Gas Inspector.

It is very important for the success of any national process try to obtain a full commitment between all the sectors involved so that certificated employees could be admitted and payed in a different way as those without job skills certification.

Government institutions and construction sector must do a commitment for improving Skill Job Evaluation System.

It is necessary to consider workers skills certification take place every 3 or 5 years because of the evolution of technology and rules involved. In relation to those workers who have reproved the certification they have to do it after a period of time in order to guarantee they have been trained or at least they have practised and go deeper into the reproved subjects. In this situation, we suggest a space of time no less than 6 months.

It is essential that registries of certified and not certified workers might be published. Specially, in the case of free workers, registries must be available.

Due to the current global interchange our country is continually receiving a great number of devices and equipments with technology that requires trained manual labour. That is why an evaluating and certification system must consider this variable.

Countries interested in putting into practice evaluation and certification job skills systems have to adjust proved systems to their own facts and particularly to workers educational levels and the technological development of the construction area.

Before carrying out an evaluation and certification job skills process it is necessary to consider a financed continued training program for the manual labour. Competencies definition must be done by all the involved organisms but going from an in situ study of all the tasks the worker habitually does. In many countries in developing process there are workers in the gas and electricity home service who work by their own, This situation is also found in Chile and it was very difficult for these workers to take part of the process because they did not have the appropriate educational level as to approve written tests, did not have the habit to register evidences of the works done and did not have an appropriate knowledge of the existing set of rules. So in Chile, these workers could not participate in the process or in some cases they had to leave it at preliminary stages, and only a very low percentage could end the process.

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A competency framework for construction supervisors in developing countries

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Abstract
This paper analyzes the role of construction site supervisors, including foremen and general foremen, as front-line managers. The role is treated as a critical labor function and a source of value-added for construction management. An original model based on the labor competency management framework is proposed for training, developing and certifying construction supervisors in Chile and other developing countries. This model was developed from the findings of a case study in which the competency framework was applied to a specific construction company. This case study has demonstrated the significant potential of the competency framework for the Chilean construction sector, with its underdeveloped human resources management methods. The application of the competency approach might help to greatly improve the human resources management function in construction companies as well as the site performance of their personnel.

Keywords: Construction, site supervisor, competency profile, management, competency model.

INTRODUCTION

The labor competency management approach is currently applied in many developed and developing countries [Mertens, 1996]. However, there is as yet no single definition of the concept of competency. For example, according to Spencer and Spencer [1993], competency is an underlying characteristic of the individual that is causally related to a standard of effectiveness and/or to a superior performance in a job or situation. Mertens [1998], on the other hand, defines competency as the capacity demonstrated by a person to achieve a result that may or may not become an effective contribution.

This labor management concept attempts to transform workers traditionally oriented only toward production and the carrying out of prescribed tasks into actors who go beyond what is prescribed, putting actions into practice and able to react to events; in short, to make a contribution to their job [Le Boterf, 2001].

In the competency labor management approach, personnel management becomes a strategic area where the management of talent is aligned with the objectives of the business as well as its vision and mission [Vargas, 2002]. With the implementation of a competency framework, personnel are seen as the main source of value added [Alles, 2000].

A good human resources management function should be aligned with the strategy of the organization, and this can be efficiently achieved through the application of the competency approach. Some have pointed out, however, that there is always a risk that human resources systems can damage an organization's competitive advantages, inhibiting the mobilization of new competencies or the appropriate exploitation of existent ones [Lindgren et al., 2004]. In the case of the Chilean construction industry, the development of workers' competencies is so inadequate that any action taken on human resources will likely produce a significant improvement over the current situation.

In this article, we describe the application of the competency labor management framework to the management of human resources in a Chilean construction company. Our analysis will focus on just one of the various employment positions typically found in such an enterprise, which is the construction site supervisor function. Included in this job category are general foremen and foremen. The role of the site supervisor is discussed and interpreted as a "critical labor function" due to its impact on site productivity, quality and general site performance and its importance for achieving the objectives of a construction project.

THE CONSTRUCTION SITE SUPERVISOR'S ROLE

Construction site supervisors are responsible for directing the execution of basic construction project work operations, as well as for communicating the project's objectives and goals to the workers. They are in permanent contact with site personnel, responding to their needs and observing and checking their performance. Also, supervisors must implement general planning guidelines at the construction work level, serving as a nexus between the site manager and the workers. This requires that supervisors prepare work plans and communicate them to the workers charged with their execution.

Due to their close involvement with site activities, supervisors' management efforts impact directly on the productivity and final quality of the work they are responsible for. Their performance is thus of particular importance for achieving a project's objectives.

On-site observation has shown that the role of these supervisors is subject to various restrictions. Some indications of this phenomenon include the following [Serpell and Ureta, 1989]:

- Supervisors are generally excluded from improvement and training programs. Most of them have not finished secondary school and their professional development consists mainly of on-the-job experience and learning from more experienced site personnel.
- Their authority to make decisions is usually quite limited owing to the fact that they are considered as workers instead of site managers.
- They are restricted to functional tasks and are lax in the control they exert over their workers.
- Their status is relatively low in the eyes of the workers, who are aware that they (the supervisors) are not clearly supported by management or consulted on decision-making.

According to a Chilean Construction Chamber study [1993], there are serious weaknesses in the training of site supervisors (general foremen and foremen) and a lack of middle-level professionals or technicians with one or two years of specialized training in construction for supervisory positions. Among the most important deficiencies currently encountered in the construction sector as regards site supervisors, we may mention the following:

- A lack of formal training to qualify site supervisors for taking on supervisory responsibilities. There is no an official supervisor job definition to orient their training.
- Current training activity is insufficient to supply the number of supervisors required by the market.

- The lack of appropriate training for site supervisors increases construction costs due to their inability to carry out work planning, communicate effectively with workers or properly direct work activities.
- Inappropriate supervisory personnel selection processes. Supervisors tend to be workers with experience in site work and strong personalities that set them apart from their fellow workers, but without formal knowledge or training in management skills.
- There is no national qualification system that evaluates and certifies site supervisors. Their skill qualification levels are set by each individual company, thus creating a supply of supervisors that is neither uniform nor comparable.

In the last few years, some Chilean construction companies have begun to change their view of the site supervisor's role and are implementing a new vision of the position in their organizations. On this approach, site supervisors are seen as first-line managers, meaning that their function is recognized as belonging to the management level. The focus of the supervisor's management role is thus to direct the basic work processes for executing construction. This means that activities formerly the preserves of higher management levels are now becoming part of the site supervisor's work at the operating level. In this context, supervisors are a crucial comunication link between senior management and team in organizations, because they are closer to the daily operations and customers [Mc Neil, 2004].

In this new role, supervisors are now qualified to design, develop and manage their work teams for performing construction work. The new leadership function for directing the members of their teams has thus become another required competency.

APPLICATION OF THE FRAMEWORK

In this section we present the results of a specific application of the competency-based labor management framework to the site supervisor's job at a Chilean construction company. Founded in 1981, the company specializes primarily in the following construction markets: buildings (more than 400,000 square meters constructed), water and sewage, roads and highway and other civil infrastructure. Though a relatively young company, it already possesses a strong organizational culture that promotes the participation of all employees within the organization.

The actual implementation of the framework involved designing an education and training plan based on labor competencies. Development of the plan was completed in five months. Our study began with a series of meetings with the company's Quality Management Coordinators Committee, the entity in charge of the project, to gather information about the objectives and requirements of the organization as they affected the design of the training plan. Once the project scope was defined, an analysis of the business process was initiated and the company's critical labor functions were thus identified.

The competency profile development stage included many meetings with personnel who performed the various labor functions under analysis so as to better identify the required competencies for successful job performance.

Once the different competency profiles had been developed, the skill levels of personnel who performed the various labor functions for which competency profiles were defined were then evaluated in order to identify the training gap and subsequently define a training plan for the company. It was then possible to identify those critical competencies the personnel in question were lacking and initiate the necessary training processes.

As part of the application of the competency-based management framework, an implementation model was developed and is shown here in Figure 1.

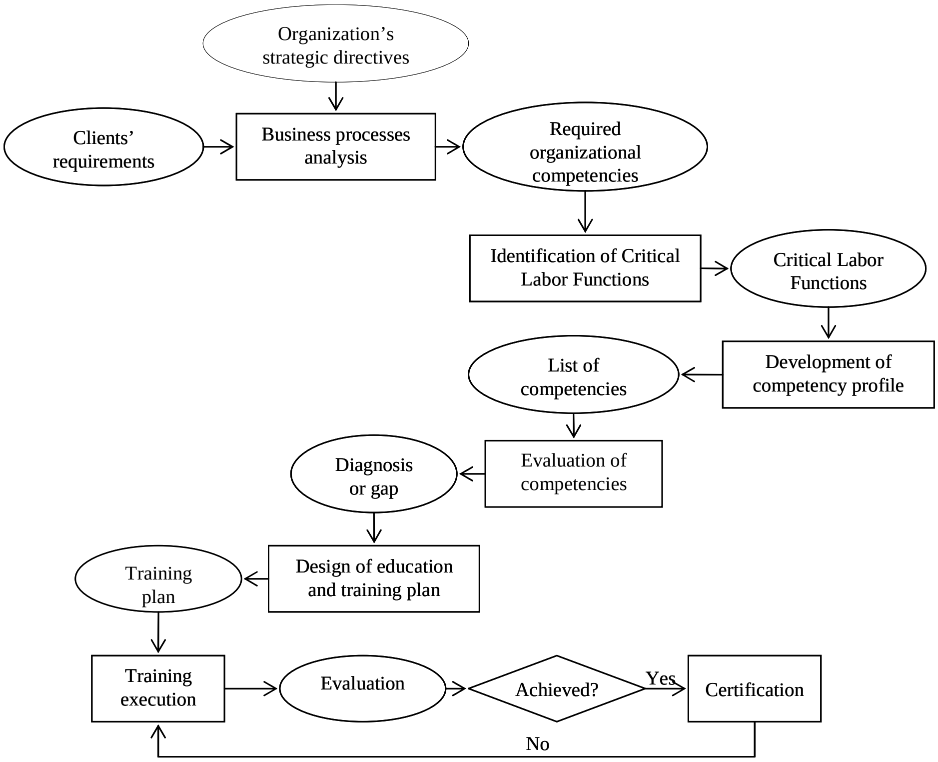

Figure 1 Competency-based labor management implementation model (ovals represent inputs or results and rectangles represents activities)

Analysis of business processes

The purpose of this stage was to analyze certain items of information that were relevant to the purposes of the company. One such item was the organization's strategic directives; another was its clients' requirements. The idea was to align the competency approach with the company's business priorities in order that the competencies developed were those that were genuinely required.

Emerging from this analysis were the principal required organizational competencies. One of these competencies was the occupational category of site management.

Identification of Critical Labor Functions (CLF)

Using the information generated in the previous stage, the main critical labor functions for each organizational function were identified. In the site management occupational group, "site supervision" was identified as a critical function, although initially the function's title was left open. At this point the emphasis was on the function itself rather than its formal title or name.

As well as identifying this function, an analysis of the specific characteristics of its "business process" was carried out, covering the purposes of the process, its critical characteristics and its specific outputs. In addition, the function's relationships and its coordination with client and supplier processes were specified. Performance indicators for the business process were also defined in this stage.

Development of the competency profile

The background information obtained in the first two stages of the analysis was employed in the third stage, which consisted of determining the site supervisor's competency profile. The first task was to specify the title of the function, which in this case was "site supervisor." The purpose of the function was then described in terms of the site supervisor's main activities and formulated in such a way as to express the specific actions involved (to supervise, to plan, etc.). This was followed by a breakdown of these activities, beginning with the most general and proceeding to the most detailed, the latter including the planning of operational processes, leading work crews, and supervising work progress, among others.

A third level of breakdown described the "critical activities" with a sufficient degree of detail as to correspond to the specific responsibilities of a site supervisor. This was done in such a manner that responsibilities were not identified with tasks, as it was expressly desired to avoid the confusion of the two. The analysis for the labor function of site supervisor is shown in Figure 2.

The information and descriptions generated up to this point were enough to establish the knowledge, attitudes and behavioral attributes a site supervisor should possess in order to achieve a proficient performance level. A correctly drawn-up profile will contain the elements necessary for an effective subsequent evaluation of the competencies involved. Figure 3 shows the competency profile of the CLF under analysis that was obtained using the aforementioned procedure. The main output of this stage was the list of competencies for the site supervisor function.

<table>
<tr><th colspan="2">Purpose: to supervise and coordinate the execution of the critical activities in the operational work in accordance with project plan</th></tr>
<tr><td rowspan="3">To plan the site and operational processes in accordance with tactical plan of construction project and company policies</td><td>To plan and implement operational actions of work teams in accordance with project cost, time, quality and safety indicators</td></tr>
<tr><td>To distribute and control resources required by basic site operations in accordance with process plan and quality standards</td></tr>
<tr><td>To coordinate execution of site activities at the different work faces based on operational plan</td></tr>
<tr><td rowspan="3">To lead internal and external work teams carrying out project construction in accordance with personnel management policies of organization</td><td>To assign functions and their responsibilities among the different construction process stages in accordance with project's human resources plan</td></tr>
<tr><td>To involve internal and external construction workers in quality system, safety and environmental practices in accordance with corporate policies</td></tr>
<tr><td>To train and evaluate competencies of construction workers involved in basic construction processes in accordance with corporate and project policies</td></tr>
<tr><td rowspan="3">To supervise the progress of construction activities and their execution, ensuring compliance with the organization's quality system, safety and environmental standards</td><td>To supervise the fulfillment of construction objectives while ensuring compliance with legal safety and environmental regulations and company policies</td></tr>
<tr><td>To measure progress of construction activities in accordance with project's tactical and operational schedule</td></tr>
<tr><td>To report the state of progress of operational activities based on performance indicators and operational plan measures</td></tr>
</table>

Figure 2 Critical activities of the site supervisor

Competency profile	
Education and training	• Understand the concepts and elements of the tactical and operational planning of a construction project. • Distinguishes and evaluates construction materials and equipment frequently used in construction projects. • Recognizes the different construction techniques. • Distinguishes and applies quality, safety and environmental procedures.
Abilities and performance	• Leads operational working teams and involves them in operational planning. • Involves people in safety, quality and environmental practices. • Plans construction projects at the operational level. • Applies management tools to evaluate the progress of construction projects and evaluates quality.
Attitudes	• Oriented to the mission and vision and strategic goals of the project. • Committed to the organizational values of the company. • Committed to the safety of personnel and the security of material resources. • Flexible and able to adapt in the face of aggressive environments and situations.

Figure 3 Competency profile of the site supervisor

Evaluation of competencies

The evaluation of the site supervisor's competencies consisted of measuring their current competency levels against those established in the competency profile for the position. More precisely, the outcome of the supervisor's actions should be measured against the standards established in the competency profile.

In our study we administered a competency proficiency survey to a representative group of each of the organization's critical labor functions in order to evaluate them in terms of the competency profiles. In the case of site supervisors, 24 persons were so evaluated. The results showed that in very few cases were the supervisors proficient in the required competencies. The complete findings for the three evaluated competency units are shown in Table 1.

Table 1: Results of the survey of site supervisors' competencies.

Competency unit	Proficient (%)	Satisfactory (%)	Unsatisfactory (%)
Planning of site operative processes	8.3	62.2	29.5
Leading internal and external teams	4.2	87.5	8.3
Supervision of progress of site activities	4.2	83.3	12.5

Those who satisfied more than 90% of the evaluation elements constituting a competency unit were ranked as proficient; those who satisfied 61% to 90% were deemed satisfactory; and those who satisfied only 41% to 60% or less were classed as unsatisfactory. For every competence unit, there was some persons who did not satisfy at least one such element.

The final result of this stage of our model was to define the gaps between the competency profile standards and the actual demonstrated competencies of the company's site supervisors at the time the evaluations were conducted. It was found that not one supervisor successfully passed the evaluation. The gaps discovered were then interpreted in terms of training needs.

Design of the training plan

The training plan developed during our implementation of the labor competency model left aside all considerations not related to the competencies found to be required when the training needs were defined (in the previous stage). Once the problem (i.e., the gaps) was fully defined, the purpose or general objectives of the training actions were established and the specific competency units that needed to be addressed were selected for inclusion in the plan. The training methodology was also defined, giving special emphasis to those activities that involved the participation of the trainees. It is important that the training be highly individualized, both as regards the teaching methods and the evaluations. Group-level assessment was avoided.

The training plan further included a monitoring stage to check on how supervisors put into practice at the work site their newly acquired competencies, plus an evaluation after a period of three to six months following training. The purpose of the evaluation was to measure the real impact of the site supervisors' new competencies on their workplace performance.

Execution of the training plan

This stage was not implemented during the application of our model. Once the design stage was completed, however, the construction company began the process of selecting training providers. This is a critical activity for ensuring the training will be effective and achieve the desired results.

Evaluation

Our evaluations of site supervisor competency were not conducted with a view to gathering sufficient data for the certification of candidates for this function. Nevertheless, it was explained to the company that as the implementation of the labor competency framework progress and human resources personnel develop their expertise in the competency management approach, changes would have to be made to company practices on performance evaluations, which at the time of the study were done using strictly quantitative indicators.

Summary and conclusions

This application of the competency approach to a particular firm has not yet been completed, and it is still too early to evaluate its impact on company personnel. More time is needed to study all of the potential impacts. We may conclude, however, that the structured approach of the competency framework can help businesses develop more objective schemes for the design and implementation of training and for management of human resources in environments where these functions are currently inadequate.

As regards the construction site supervisor, by defining the position as a management function, it takes on a strategic position in the company's organization chart, and the business process related to it becomes a critical one. The function is then no longer limited to the bureaucratic supervision of tasks, having assumed a much more active and committed role within the global strategy of the organization. Thus, the site supervisor now carries out activities that are a source of value added to the organization.

Chilean construction companies, whose human resource practices are generally very traditional, are not yet able to adopt a human resource management approach in the sense of considering people as a strategic factor. The labor competency management framework, given that local conditions are taken into account, can serve as a very useful alternative to change this reality, given that:

- The labor competency approach favors the development of the entire range of a person's attributes.
- With the labor competency scheme it is possible to address new requirements for the site supervisor, most notably the management competencies whose performance indicators are qualitative rather than quantitative.

Some of the principal characteristics of the competency framework that were considered functional by the construction company when deciding its application to the construction site supervisor, are the following:

- The value added of a function can be understood as the level of a person's contribution in terms of the production of output, the fulfillment of objectives and the achievement of strategic goals.
- The determination of the critical activities of a function requires an exhaustive analysis of the site supervision process and its numerical and non-numerical performance indicators. In traditional practice, which is more functional in nature, the focus on processes has been absent.
- Job description manuals are replaced by competency profiles or standards that must be periodically revised. The competency profile has a generic character and to a certain extent it exists outside of the actual job context, a fact that radically differentiates it from the task itself.
- Performance evaluation based on the quantity of tasks carried out by the site supervisor does not aid in measuring the value added of the supervisor's work. What should be measured are competencies, a system of measurement implemented using diverse strategies but always involving comparison with a competency profile or reference.

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Eliminado: *Countries*

Women, Construction, and Health and Safety (H&S): South African and Tanzanian perspectives

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Abstract

Construction by its very nature constitutes a challenge in terms of health and safety (H&S) and ergonomics as it exposes workers to a range of health, safety, and ergonomic hazards, manual handling included. Internationally, women constitute a minor percentage of the construction workforce. Furthermore, perceptions exist that women are not suited to construction, that construction work is too physical for women, and that the image of the industry discourages participation by women. Whether or not perceptions are just, they are important as people act on them.

A study was initiated to determine perceptions relative to: participation of women in general; their role; their capacity; their impact; their potential contribution; barriers to their participation; and general and gender specific issues. The paper reports on studies conducted in South Africa and Tanzania, the salient findings being: women have a role in construction; increased participation by women will contribute to improving the image of construction; women have requirements related to their gender and roles; some construction materials constitute a manual materials handling problem to women, and current welfare facilities for women are inadequate. The paper concludes that endeavours are necessary to change attitudes, promote participation by women, accommodate women, and improve conditions, particularly H&S.

Keywords

Women, construction, health and safety

INTRODUCTION

South African construction workplaces appear to exclude women: rarely are women visible on sites or in professional positions. A study of 200 construction workers in the Western Cape that covered a comprehensive economic range of 65 sites did not reveal one woman (English, 2002). Women have had a lower level of education than men and possibly this has increased unemployment for them, and men have dominated the workplaces (Statistics South Africa, 1999). The South African

Construction Industry Status Report describes women as representing a mere 8% of the building and construction management profile in the formal sector (Construction Industry Development Board, 2004).

Employment in the construction industry according to the 2001 census was 520 486 altogether, 470 909 of whom were male, 46 577 female. Almost half employment in the industry occurred in the informal construction sector, which in 2001 was 223 000, 206 000 of whom were male, 18 000 female (Kane-Berman, 2001). However, there are some positive indicators of this profile changing. The informal sector reflects female involvement existing through the South African Women in Construction (SAWIC), which reports a membership of about 600 building enterprises owned by women (Department of Public Works, 2004). This is in keeping with the commitment stated by the departments of Public Works and of Housing, and the Construction Education Training Authority (CETA) to increasing the number of women participating in the industry (CETA, 2000). To achieve these goals, however, it is necessary to review inherited problems of the past, the attitudes to women presently entering construction and, having entered the industry, staying in it (Dainty and Bagilhole, 2000). Attitudes of women who have not considered construction as a career should also be sought.

In employment of women, there is no general global model through the UN has presented various initiatives (United Nations Conference on Women, Mexico 1970; United Nations Millennium Development Goals 2000). For those countries with stable economies and established education systems, e.g. Australia, Britain and the United State of America (Bullock 1994; Fielden et al. 2001; Graham and Hotchkiss 2003), the argument for employing women is to:

- provide equal opportunities to those wanting to join in a non-traditional occupation;
- appreciate the advantages women may offer to both industry and society by being accommodated in male dominated professions;
- acknowledge many work places and the men working in them may be hostile to women;
- ensure management directives which will equalise recruitment, employment, pay, job placement, promotion, and job retention, and
- address the shortage of skilled and unskilled labour in first world countries.

Research by Dainty *et al*. showed that strong stereotypes of women's choices for their careers have been found to be held by employers. This stereotyping is reflected in recruitment biases and in the findings that in the UK, women leave construction and that only 25% of women in construction believe they can develop careers (Dainty, Neale and Baglihole, 1999). Research conducted in Australia (Department of Employment, Education and Training, 1993) indicates that it is the lack of effective communication between industry and girls / women that is the cause of a low profile of women in the industry. Findings were that women need to be able to access information about the specific aspects and tasks involved in trade work and that they are not able to through general knowledge (Department of Employment, Education and Training, 1993). It would seem from models in Europe that political good will to encourage employment of women is insufficient to elicit change and that only when equal opportunity actions that targeted women were implemented was there a change (Michielsens, 2004). In addition, the recruitment literature of the Construction Industry is gender based, offers no career advice to women, and the industry generally is unaccommodating of women entering (Wall, 1997). Research has also indicated that discreet or overt discrimination against women in the workplace results in women leaving their jobs (Morley, 1994). This is also true of other occupations, which are male dominated: whilst performance in the job of women as equalled that of male colleagues, the environment has been too hostile for them to remain (Bullock, 1994). And as most of these women are working in the formal sector, the options for their position being changed are reduced.

The aspect of health and safety (H&S) is of particular concern as women in South Africa in attempting to enter the construction industry can be presented with the added burden of working in unsafe conditions. The high unemployment, many impoverished people and no shortage of male labourers leaves women with no direct role in construction except as lowly paid helpers, moving earth, bricks and mortar, or making bricks. These jobs are conducted under poor working conditions that can be detrimental to H&S. Thus before promoting women in the SA industry regard must be paid to H&S. This paper is based on a study conducted in 2004 in South Africa and 2005 in Tanzania of attitudes held by senior representatives and stakeholders in the industry.

The objectives of the study reported on in this paper were to determine their perceptions of the following aspects concerning women in construction: participation of women in general - their role; capacity; impact, and potential contribution; barriers to their participation; general and gender specific issues, and engendering of their participation.

RESEARCH

Methodology, sample stratum and response

The South African sample stratum was comprised of thirty-seven delegates attending two one-day Construction Regulations Workshops in two metropolitan areas over a two-day period. A survey questionnaire was circulated at the start of the first session for completion by its end. The gender ratio of the respondents was 81.1% male and 18.9% female. Thirty-seven questionnaires were included in the analysis of the data, which equates to a response rate of 100.0%.

The Tanzanian sample stratum consisted of twenty-four delegates attending a four-day Certificate Programme in Construction H&S in Dar Es Salaam. The gender ratio of the respondents was 82.6% male and 17.4% female. Twenty-three questionnaires were included in the analysis of the data, which equates to a response rate of 95.8%. It should be noted that such a high level of response to surveys conducted during workshops and programmes is not the norm which indicates that the subject area is probably topical. In terms of the stakeholder constituency of respondents, architects predominated relative to South Africa, followed by quantity surveyors, and contractors. Relative to Tanzania, architects and engineers predominated, followed by contractors.

Analysis

- The analysis of the data consisted of the calculation of descriptive statistics to depict the frequency distribution and central tendency of responses to fixed response questions. A five-point scale was used to determine the: degree of concurrence relative to a range of statements.

Findings

Table 1 indicates the extent to which respondents concur with the various statements in terms of percentage responses to a range ‘strongly disagree’ to ‘strongly agree’, and in terms of a mean score ranging between 1 and 5. Mean scores above the midpoint score of 3.00 indicate that in general the respondents can be deemed to concur with the related statements, and those ≤ 3.00, that in general the respondents cannot be deemed to concur with the related statements.

Only one statement realised a mean level of concurrence > 4.20 ≤ 5.00, which means that the degree of concurrence is between agree to strongly agree / strongly agree, namely: "Women have a role to play in construction." Given that the greater percentage of respondents is men; this is a notable level of concurrence. Furthermore, it suggests that attitudes have shifted since the findings of the UK study which determined that women leave construction and that only 25% of women in construction believe they can develop careers (Dainty, Neale and Baglihole, 1999). Research by Wells (1990) indicated they play virtually no part in the formal sector, and Dainty and Bagilhole (2000) state that it has been suggested that they do not do so because of both active discrimination against their entering it, and their consequent reaction to the barriers, which reinforces their feelings of alienation. The findings of this paper suggest the climate is more conducive to women. Although Wells (2004) cites a 14.6% increase in women employed in construction in five Asian countries, the statistic for women in production work is in fact 66%. Other research cited women in India who, whilst accounting for over 28% of the workforce in the Construction Industry, work predominantly in unskilled occupations such as head load carriers or cleaners and are offered no opportunity to develop skills (Vaid, 1999).

The next range of mean scores > 3.40 ≤ 4.20, means that the concurrence is between neutral to agree / agree.

The finding of Dainty and Bagilhole (2000) that the construction industry is considered to have one of the most negative public images of all industries is reflected in the concurrence relative to: "Increased participation by women will contribute to improving the image of construction." The concurrence also reflects the potential role of women in improving the image, the poor image being attributed to, inter alia, its reputed working practices. The biological differences between men and women are reflected in the high level of concurrence relative to "Women have 'special' personal hygiene issues / requirements." This concurrence can be linked to the high level of concurrence relative to the statement "Current welfare facilities for women are inadequate." The level of concurrence to the latter is notable, as a previous South African study conducted by Smallwood (2004) determined that performance relative to welfare facilities was rated between very poor to poor. The statement "Women are likely to be sexually harassed on site" attracted a high level of concurrence. Research conducted in countries where women are on site in skilled as well as unskilled positions illustrate unpleasant, and even life threatening instances of harassment on site (Eisenberg, 1998).

The high level of concurrence relative to "Some construction materials present a manual materials handling problem to women" is not unexpected as Schneider and Susi (1994) contend that construction by its very nature constitutes an ergonomics problem. However, it should be noted that the mean score relative to "Some construction materials present a manual materials handling problem to men" is marginally below that relative to women, namely 3.71 vis-à-vis 3.54, the former being 6.7% higher than the latter.

The concurrence relative to the statement "Mechanisation of the construction process will promote participation by women" should not be reviewed solely relative to women, as the potential contribution of mechanisation to an improvement in ergonomics has been identified in previous South African studies (Smallwood, 2002). The level of concurrence relative to "Women are not respected to the same extent men are" is both supported and not supported by the findings of literature. Whilst the inclusion of women is positive, it is only so if they are recognised and their rights regarded. An aspect of discrimination that continues to be perpetuated is the image of women as minor wage earners and of their being less competent in skilled work than men contribute to their being given and accepting lower wages (Bullock, 1994). An active example of this is women in construction are in services rather than in production – as many as two thirds in Africa (Bullock, 1994).

However, some recent projects indicate that women are being positively received and are possibly experiencing a more supportive environment at work. A female bricklayer in Botswana who, having met with resistance from employers, none the less described her work experience in overall positive terms: *I do not experience any problems as a female bricklayer – both male and female colleagues respect me. It is not difficult to get work as a bricklayer* (Rantshadi, 2004).

The concurrence relative to the statement "Older (> 40 years) women are less suited to the physical construction process than men of the same age" indicates that the perception is perpetuated. However, it should be noted that a previous South African study determined that construction is not complementary to older workers, in general (Smallwood & Haupt, 2004).

The next range of mean scores $> 2.60 \leq 3.40$, means the concurrence is between disagree to neutral / neutral.

The non-concurrence / neutrality relative to "Women are not as physically capable as men" is supported by literature. However, the statement "Women are as physically capable as men" attracted even less concurrence. It is pertinent to note that traditionally African women have been used to undertaking physical hard labour in agriculture and construction. It has only been in recent history, through colonial practice, that they have inherited a system where men have taken over the labourer's role in construction (Wells 1990; Vaid 1999; Dainty and Bagilhole 2000; Budlender, 2002). A further irony is that women were once the architects and builders of homes in Africa. Kalambu (2001) describes research conducted in different parts of Africa, which indicates that women undertake various physical building tasks such as mixing and moulding bricks, building walls, cutting and setting up roofing poles and thatching. With Western influences on African societies, gender roles have become more Eurocentric than African and women have ceased to play a pivotal role in the creation of housing (Kalabamu, 2001).

The non-concurrence / neutrality relative to "Women are less likely to accept unsafe conditions than men" and "Women are less likely to accept inadequate welfare facilities than men" indicate that women are not more receptive to unacceptable circumstances than men. Although studies have indicated that climbing and descending constitutes an ergonomics problem in South Africa, the non-concurrence / neutrality relative to the statement "Current provision for vertical movement (access) on site is inappropriate for women" does not reflect these findings (Smallwood, 1997; Smallwood, 2002). The statement "Appropriate work attire is not readily available for women" is not concurred with; neither is the statement "Generally personal protective equipment (PPE) is not suited to women." The statement "Women are less likely to be willing to work in extreme temperatures than men" attracted non-concurrence / neutrality. The statement "Appropriate work attire is not readily available for women" is not concurred with, and more so,

The non-concurrence / neutrality with the statements "Women are more suited to administrative than production functions on site" and "Women are as physically capable as men" both reinforce the highest level of concurrence received by any statement, namely “Women have a role to play in construction.” The non-concurrence is notable in that most respondents are male. However, a realistic concern and one that is entrenched universally, namely that the nature of the work will present many problems needs to be discussed as it has been identified as a barrier. Fielden and Davidson (2000) argue that the negative factors in the construction industry working environment are considered particularly unsuitable for women, and, for example, the UK industry is devoid of female labourers. However, they maintain that this is more from traditional gender-entrenched attitudes, as many facets of the job are now not dependent on manual strength, as they are supported by machines. In the USA, women for some time have participated in construction trades such as electrical, but are still poorly represented in the industry (Eisenberg, 2001). In one study undertaken in South Africa, women cited the following tasks as being ones they could easily manage in building: clearing site (82%); painting (88%); stock control (91%), and book keeping (92%) (Marshall, 2002). Some women interviewed described activities they had been involved in during the construction of their own homes: preparing the site and shifting the shack to accommodate the house to be built; digging foundations; mixing concrete and cement mortar; packing and carrying bricks; collecting materials by wheelbarrow; fetching sand and concrete, and passing bricks (Marshall, 2002).

The model that this study could develop would see women with needs and abilities being given access to training and employment and working in activities in construction that do not necessarily require physical strength. Therefore, a critical path for women’s entry into the industry is for their roles on site to be suited to them; roles which they ultimately fill more effectively than their male counterparts. For example, in Belgium, women are well represented as house painters (Susman, 2003). A study in India described suitable areas of skill for women as tiling, flooring, painting, plastering, finishing and such trades (Chitale, 1999).

The statement “Ultra violet radiation poses more of a threat to women than to men” attracted non-concurrence / neutrality. The next range of mean scores $> 1.80 \leq 2.60$ means that the concurrence is between strongly disagree to disagree / disagree.

Although the statement “Transport to and from, and between sites is inappropriate for women” is not concurred with, literature indicates that transport of workers in South Africa is inappropriate and constitutes non-compliance with the transport related provisions of the Construction Regulations (The Civil Engineering Contractor, 2005). Literature does not support the non-concurrence with the statement “Generally personal protective equipment (PPE) is not suited to women.” A study conducted on a platinum plant in South Africa determined that small enough boot and overall sizes were not available for women engineering recruits (English, 2004).

The non-concurrence with the statement: “Women are more likely to be absent from work than men”, is supported by literature. Female craft workers have been found to be more reliable, produce better quality work and practise sobriety (Boiko, 1994). In a study in Botswana, contractors and foremen who had employed women out of a skills’ shortage necessity, stated that most female workers were more committed to their work than male counterparts, being absent less and not requesting daily wages (Kalambu, 2004).

Furthermore, the following significant differences between countries in terms of mean scores relative to statements should be noted: women are likely to be sexually harassed on site; women are not respected to the same extent men are; older (> 40 years) women are less suited to the physical construction process than men of the same age; women are less likely to accept unsafe conditions than men; current provision for vertical movement (access) on site is inappropriate for women; appropriate work attire is not readily available for women; women are less likely to be willing to work in extreme temperatures than men; women are more suited to administrative than production functions on site, and Women are more likely to be absent from work than men.

A comparison of the mean scores relative to gender and countries was drawn up but is not included given the constraints on paper length. Respondents were also asked a summary question in the form of: Would you be prepared to work on the average construction site as a woman? Table 2 indicates that slightly more than the minority would be prepared to work. However, although slightly more than a quarter indicated that they would not be prepared to, as much as 33% were unsure.

Table 1: Comparison of 'overall' South African and Tanzanian degree of concurrence.

	South Africa		Tanzania		Mean	
Statement	**Mean score**	**Rank**	**Mean score**	**Rank**	**Mean score**	**Rank**
Women have a role to play in construction	4.14	1	4.27	1	4.21	1
Increased participation by women will contribute to improving the image of construction	4.03	2	4.16	2	4.10	2
Women have 'special' personal hygiene issues / requirements	3.86	3	3.95	4	3.91	3
Women are likely to be sexually harassed on site	3.53	6	4.09	3	3.81	4
Current welfare facilities for women are inadequate	3.67	5	3.90	5	3.79	5
Some construction materials present a manual materials handling problem to women	3.70	4	3.71	6	3.71	6
Mechanisation of the construction process will promote participation by women	3.51	7	3.50	9=	3.51	7
Women are not respected to the same extent men are	3.23	9	3.70	7=	3.47	8
Older (> 40 years) women are less suited to physical construction process than men of the same age	3.20	11	3.70	7=	3.45	9
Some construction materials present a manual materials handling problem to men	3.47	8	3.38	13	3.43	10
Women are not as physically capable as men	3.19	12	3.48	11	3.34	11
Women are less likely to accept unsafe conditions than men	3.06	13	3.50	9=	3.28	12
Women are less likely to accept inadequate welfare facilities than men	3.22	10	3.29	15	3.26	13
Current provision for vertical movement (access) on site is inappropriate for women	3.00	14	3.43	12	3.22	14
Appropriate work attire is not readily available for women	2.89	15	3.32	14	3.11	15
Women are less likely to be willing to work in extreme temperatures than men	2.62	18	3.20	16	2.91	16
Women are more suited to administrative than production functions on site	2.51	21	3.17	17	2.84	17
Women are as physically capable as men	2.81	16	2.74	19	2.78	18
Ultra violet radiation poses more of a threat to women than to men	2.63	17	2.60	20	2.62	19
Transport to and from, and between sites is inappropriate for women	2.58	19	2.57	21	2.58	20
Generally personal protective equipment (PPE) is not suited to women	2.57	20	2.45	22	2.51	21
Women are more likely to be absent from work than men	2.06	22	2.90	18	2.48	22

Table 2: Preparedness to work on the average construction site as a woman

Response	Response (%)		
	South Africa	Tanzania	Mean
Yes	38.9	38.1	38.5
No	33.3	23.8	28.6
Unsure	27.8	38.1	33.0

CONCLUSIONS

The construction industry is short of skills. Providing able skilled labour through the employment of women on sites will contribute to the eradication of poverty, as it would facilitate an improved rate of construction and quality of building. However, the example of Asia must not be followed - women must be trained in skills and recognised for the work they do. As unskilled labour their presence is more easily disguised and as the industry becomes more mechanised, their jobs diminish (Wells, 2004).

Based upon the findings of the surveys reported on it can be concluded that there are positive perceptions with respect to the role of women in the construction industry. However, it must be noted that the respondents were predominantly consultants and from management, and are therefore likely to constitute the more enlightened participants in construction.

The findings of the surveys also lead to the conclusion that the industry projects a poor image, and that the welfare facilities are inadequate. The importance of welfare facilities is amplified by the finding that women can be deemed to have 'special' personal hygiene issues / requirements. It can also be concluded that the industry entails a large amount of manual handling, that vertical movement of people requires attention, and that there is a need to mechanise the industry.

Therefore, to realise enhanced participation by women in the industry will require a paradigm shift and re-engineering of the industry. The industry needs to become more of a process industry (incorporating a high level of mechanisation and use of plant and equipment) than a craft industry. Although there are proponents of labour intensive construction manageable for women, the realities are that construction in general constitutes barriers to women. To change them: awareness, followed by acknowledgement and commitment is needed.

The study also considered pragmatic concerns such as issues around hygiene, sexual harassment and respect which all impact on women more than on men. There is concurrence relative to the work environment not meeting the personal hygiene issues / requirements of women, that women are likely to be sexually harassed on site, and that women are not respected to the same extent that men are.

An option for enabling women to enter the construction industry is for training to take place on site. Evidence of women's ability to learn on-the-job can be seen in the successful ventures of women building the enhancements and subsequently moving on to manufacture. Another option would be mobile training units which could train women in building skills. This system of training was alleviating the cost of cars bought to and from training in use. Training on-site is perceived by some research to be the most viable option for a subcontracted workforce (English, 2002). South African women, who at present participate in building their own houses by making concrete bricks, are taught to do so on-site by people selling the brick / block making equipment (Fletcher, 2004).

Furthermore, leads can be taken from developed countries where there have been initiatives to engender more women in industries. The United States, in recognising the need for gender equity in all forms of employment to ensure parity in job opportunities for women and pay parity with men, has appointed Equal Employment Opportunity Commission (EEOC) and Office of Federal Contract Compliance (OFCCP) in an effort to encourage companies to employ women (Graham and Hotchkiss, 2003). Britain and other European countries suffering a skills shortage in the craft and manual trades, hope to fill it with women workers from Eastern European and Middle Eastern countries. This move is supported by the Equal Opportunities Commission and the British government's Women's Unit (Whittock, 2002).

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Evaluating Performance of Construction Professionals in Chilean Companies.

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Abstract

It is not new to hear that people are essential to reach success, whether we are talking about a company, a project or any organization no matter their purpose. People are the key players in a work team and they are the ones who directly determine the company efficiency. However, current performance evaluation practices are outdated and in some cases prevent innovation and implementation of improvements in contractor's organizations. For that reason, in an effort to improve human resource management, a collaborative research effort has been carried out in an attempt to empower construction professionals' capability generating a performance evaluation tool that incorporates the needs of both employees and company management.
The methodology used for developing this tool included semi-structured interviews and focus groups with different kinds of professionals in the construction industry, who contributed to the diagnosis of the current condition and assess the future need of the industry. The sample considered 6 contractors, currently involved in implementations of "Lean Construction," with projects in the areas of housing, high rise buildings, light industrial facilities and mining operations. The paper provides recommendations for the evaluation of construction professionals in a continuous improvement environment, describing necessary skills and management parameters associated to the requirements of each position.

Keywords
Personnel Performance Evaluation, Professional Construction Skills, Evaluation methodology, Organizational Development, Lean Construction.

INTRODUCTION

Many authors propose that people are essential to reach success whether we are talking about a company, a project or any organization no matter their purpose. In fact, Howell *et al.*, stated it clearly [Howell *et al.*, 2004], in reference to the construction area: "The projects are conceived and completed by people. People are the beginning, end and center of the projects. They apply tacit knowledge and establish theories drawn from science and practical observation to perform everyday actions and to innovate and solve technical problems". They are those who integrate work teams, being work teams the ones who directly determine the company efficiency. For this motive, in an effort to promote improvements in human resource management, this project has sought to develop tools that allow the companies realize the potential of people at a strategic level [Hax et al. (2004), Maloney (1997)], committing them not only with individual improvement but also with the accomplishment of each of the predefined challenges and objectives. The objective of this work was to define a methodology for performance evaluation of construction professionals to foster continuous improvement in the organization, in agreement with the needs of both professionals and senior management stated in the diagnosis.

This study, leaded by the Production Management Center of the Catholic university of Chile (GEPUC) and supported by the Chilean Chamber of Construction (CChC), is part of a more extensive investigation on organizational development. Additional work outside the scope of this paper includes: incentive systems design, management of organizational change in different kinds of projects, analysis of functional requirements and competencies for different company positions and effective time use of project managers.

METHODOLOGY

The organizational diagnosis constitutes a description of a particular organization assessing its performance. This description must be interpreted by another observant, and based on the encountered phenomena, implement a process of change [Rodriguez 2004]. Taking this definition as a reference, the methodology used to develop this study included semi-structured interviews and focus groups with different kinds of professionals in the construction area such as managers, chiefs of area, and chiefs of technical office, that contributed to the diagnosis by describing their vision of the current condition and the future projections of the companies in which they work. The sample considered 6 companies, currently working on implementation of “Lean Construction,” with a total of 45 interviewed persons and projects in the area housing, high rise buildings, light industrial facilities and mining operations. On the other hand, data of previous diagnosis made to a similar group of companies was taken into consideration [Alarcón et al., 2002].

As a result of the effort made to understand the needed competences for an adequate administration, a list of 17 competences was defined from the focus groups performed with professionals and specialized texts [Odusami, 2002]. These are shown in Table 1. Subsequently, a procedure to evaluate the priority of each one of the skills at professional level was created, in order to define a ranking (from the perspective of the ones who exercise a certain function) of the most important abilities for each position.

DIAGNOSIS

Current state

The first step was to define the current condition of the evaluation tools used by the companies, defining the professionals’ opinion regarding these. In this sense, 33.3% of the interviewed persons said that they were evaluated, 42.4% said that they believed they were evaluated, 6.1% said that they believed they were not evaluated, and an 18.2% said they were not. With regard to the question: Do you evaluate your subordinates? 55% does it in an informal way, whereas a 27% does not and only an 18% have the necessary tools to do it. Regarding the currently evaluated elements, the “accomplishment of the objectives”, especially cost and schedule, is emphasized. With respect to whom carries out the evaluation, more than a 95 % mentioned his direct boss. Most interviewed persons had a negative opinion of the current measuring system, a 70% said that they were uncomfortable with the method due to the subjectivity and lack of transparency. Nevertheless, speaking at an organizational level, it is interesting to highlight that more than 60 % believes that this system foments a good development.

Table 1. Skills identified for the study and their definition

Item	Skill	Definition
1	Communicative capacity	The skill to interact in an effective way with other people at all levels not only inside the company but also outside.
2	Decision making	The skill to take proper actions under restricted time, information and resources.
3	Delegation	The skill to delegate in an effective way the distribution of tasks to other members of the organization.
4	Financial management	The skill to understand conditions and / or financial reasons and to deal with companies related to the project.
5	Leadership and motivation	The skill to take right decisions for the company and to influence others to achieve the company's goals
6	To be able to listen	The skill to receive and to process in an effective way the information provided by others
7	Negotiation	The skill to contract considering own and others' point of view, achieving the interests of the company
8	Capacity of organization	The skill to align resources in the most beneficial way for the company
9	Planning and achievement of aims	The skill to value and to state the aims of the company finding a way to achieve them.
10	Resolution of problems	The skill to analyze adverse conditions or conflicts, identifying their causes, providing practical solutions and implementing them.
11	Quality management	The skill to manage the production of goods and services with a clear definition of (measurable) expectations
12	Technical knowledge	Understanding of complex elements required to complete tasks associated to a given profession
13	Time management	The skill to handle successfully multiple tasks with restrictions of time
14	Capacity of adaptation to changes	The skill to handle uncertainty and to adapt rapidly to the constant changes of the environment (technology, economy, MO, etc)
15	Emotional intelligence	Aptitude to feel, to deal, to control and modify both own and foreign moods and mind-sets.
16	Systemic vision	" To see the trees without losing the ability to see the forest ", that is to say, to understand the local and urgent problems, but without losing the global perspective of the project
17	Team work	To find as soon as possible a solid union within the work group in order to effectively satisfy the project's demands.

Future condition

As a proposal to enhance the current system the conditions that an evaluation tool should include were determined, not only from the management's perspective but also from the professionals who participated in it. As a first element, 60% said they would do the evaluation as a formal instrument, that is to say, with a known format. With regards to the evaluator, 91% answers that he should be the Direct Supervisor. Finally, referring to the elements that the evaluation should contain, more than 95% of the interviewed ones indicated that it should be the fulfilment of the project management's aims, understanding them as Cost, Schedule, Quality Assurance and Safety outcomes; and 60 % mentioned that it should also include the skills required for the position. The evaluation ranking of the skills for each group of professionals is shown in Table 2.

Table 2. Ranking in terms of relative importance, of skills for each position

Item	Skill	Project Manager	Chief of area	Chief of Technical office
1	Communicative capacity	9	3	13
2	Decision making	**1**	**1**	6
3	Delegation	5	3	9
4	Financial management	**17**	**17**	**17**
5	Leadership and motivation	2	2	13
6	To be able to listen	11	12	3
7	Negotiation	7	14	16
8	Capacity of organization	16	8	15
9	Planning and achievement of aims	8	13	8
10	Resolution of problems	11	11	**1**
11	Quality management	15	14	9
12	Technical knowledge	11	6	**1**
13	Time management	4	3	11
14	Capacity of adaptation to changes	11	9	6
15	Emotional intelligence	10	16	11
16	Systemic vision	5	6	5
17	Team work	3	9	3

RECOMMENDATIONS FOR AN EVALUATION OF PERFORMANCE SYSTEM FOR CONSTRUCTION EXPERTS

A considerable variety of methodologies are currently used for performance evaluation, such as the methods of graphical scales, of forced election, of field investigation, of critical or mixed incidents [Chiavenato, 2004], to which we can add the methods of narrative forms, based scales, of observation or analysis of results [Bohlander, 2001]. These methodologies also offer different options to apply the evaluation including options for who performs the evaluation performance, by means of 360° or 180° evaluations or immediate supervisors. However, the one that is more suitable to the needs found in the diagnosis divides performance evaluation in two areas. The first one, corresponds to the achievement of project objectives (Cost, Schedule, Quality and Safety), by means of the prior definition of objective targets; whereas the second one, corresponds to the evaluation of previously defined skills for each position. As it was previously mentioned, as an organizational development tool, the performance evaluation system must be in harmony with the needs stated by top management and also by the members of the project team. For this reason, after the diagnosis at least four elements can be established to discuss in the system's development process**.**

Evaluation of the achievement of project objectives

The first step for the execution of a performance evaluation is to establish a reference "baseline" for evaluation. This should be done at the beginning of the project, when the execution team is assigned to the project. This "baseline" must be formally presented to the company's senior management, which have to approve it. The formal document should include at least, an estimations of "Revenues and Cost Flows" including an updated schedule, estimated "Cash flows", a "Safety Plan", a "Quality Assurance Plan ", a "Risk Analysis" and "Points of Leverage" in the project, that is to say, to identify those elements or concepts that represent business opportunities in the development of the project.

Performance evaluation will be done contrasting reality with the plan, in an interval predefined by the company. Indexes shall be included to allow an objective evaluation of the execution of the project, such as (Real Revenue/ Planned Revenue), (Real Cost / Planned Cost), Safety Indexes, among others. Company management should assign target values for each of these indexes. Each objective must be clear, well understood and accepted by the personnel and should be used for the measurement of the management's effectiveness. In this sense, accuracy is achieved with clear goal definitions, expressed in a measurement scale that must have a value and a deadline [Campero and Alarcon., 1999]. In addition these aims must be strategic, in the sense that they must be aligned with company goals; and attainable, since an objective cannot be a source of discouragement for the accomplishment of the work [Alles, 2004].

Summarizing, the measures to evaluate achievement project objectives includes Cost, Schedule, Client Satisfaction and Safety. The evaluation uses a five level scale: A (100 %): It exceeds widely the proposed goal; B (75 %): It exceeds the proposed goal; C (50 %): It achieves the proposed goal; D (25 %): Close to achieving the proposed goal; and E (0 %): it does not achieve the proposed aim.

Skill Evaluation for each position

The second element to incorporate in the evaluation corresponds to the predefined skills for each position. In this sense it is recommended to distinguish two types of skills: the first ones, named Strategic Skills, are those that the personnel must have no matter their position in the company as they are focused to the fulfilment of the company's strategic needs. The second group, named Specific Skills, are those that depending on each position, they will be necessary to develop the assigned tasks [Alles, 2004].

Once the evaluated skills are defined for each position, every company must validate them, by contrasting them with the mission, the vision, the values they want to convey and the reality of the workplace. To define appropriate criteria concerning the skills definition, first it is recommended to define performance criteria, so as to receive feedback from a sample of suitable persons, which should conclude with the final definition that includes the definition of practice levels.

The scale recommended here contains five levels: A (100 %): Role Model, which establishes a standard of excellence in this area of competition (others see him/her as model or mentor in this area); B (75 %): highly competent, who is considered to be very efficient in this area of competition, exceeding the expectations and being over the average; C (50 %): Competent, considered as the one that is generally qualified in the competence area and being in the average; D (25 %): needs to develop, since he/her needs training to be efficient in this area of competition, since he/she is below average; and E (0 %): needs to develop significantly, since he/she needs of significant improvements to achieve efficiency in this skills area.

Evaluators and Periodicity

Regarding the evaluators, the first recommendation is – supported by the diagnosis – to implement the Evaluation of Performance taking into consideration the opinion of the Direct Supervisor. Nevertheless, it is stated that once the System of Evaluation is implemented, different evaluation agents, such as clients, subordinates and fellow colleagues, can be incorporated. The purpose is to rely on more information concerning the professional's performance, mainly at work team level.

On the other hand, a periodicity of evaluation must be defined. This periodicity will depend on each individual company. Nevertheless, the recommendation here is to evaluate the skill section once a year and the project objectives with higher frequency, that can even be done monthly or quarterly (with a new presentation of "baseline", in order to correct deviations).

Percentage Recommended as for the importance of the elements considered for the evaluation

Finally, as it has been defined, the elements to be evaluated must be in agreement with the needs and proposals of the personnel being evaluated, in order to make a transparent system of evaluation that inspires confidence. In this sense, the professionals were asked what elements an evaluation tool should contain. To this question, the organizational frequent answers were 63.6% the skills and 95.5% the project objectives, understanding the latter, as the results for Costs, Schedule, Security and Quality of the projects (all these fundamental elements from the point of view of management). These answers shows that the traditional evaluation based on project objectives is still considered the highest in importance.

Summary of elements to include in the Performance Evaluations

As it was mentioned previously, the first element to incorporate inside the organizations is an instance in which the objectives are stated for a certain period of evaluation. In this instance it is necessary to present the "Baseline" mentioned in the previous section, identifying the indexes to be used for the evaluation of the different management areas. Nowadays, most of the companies studied evaluate the fulfillment of Cost, leaving aside a deeper analysis with regards to Schedule, Quality and Safety, just as the perception of the professionals illustrates it, since no formal methodologies of evaluation exist.

As a result of the analysis of the diagnosis, it was recommended not to make differences in the evaluation of different professionals of the same team; that is, to evaluate the Project manager, Chief of Area and Chief of Technical Office with the same management parameters previously mentioned. The aim of this recommendation is to promote teamwork, the professional development of the younger professionals, and to favor the commitment of every professional to the project. In addition, according to analyses carried out concerning the functions of each position [Alarcón et al., 2005], the ideal organizational structure includes the differentiation of roles for each of the positions analyzed and included in this study, promoting that in each one of them the responsibility corresponding to the overall project management is assumed.

Concerning the weight of these elements in the global evaluation, every company has to define the importance in each of these concepts. According to the opinions perceived in the management interviews, the importance priorities of these elements have the order shown in Table 3.

Table 3. Summary of recommended Management elements for Performance Evaluation

Item	Project manager	Chief of area	Chief of technical office
1		Project Cost	
2		Project Schedule	
3		Project Quality	
4		Project Safety	

As for the transverse skills, the model proposed is for the whole organization, no matter the position involved. For the same reason, these skills should be defined by Senior Management and/or Strategic Committee of every company, being aligned by the strategy generated in that instance. Transverse skills are necessary to fulfill the company's needs as far as the personnel requirements is concerned. In the case of this investigation, the transverse, cardinal or generic skills – as they can be found in the specialized literature – were obtained from interviews with the companies' managers.

To elaborate recommendations of specific skills in each position evaluated (Manager, Chief of Area and Chief of Technical Office), the opinions of the professionals that exercise each one of the positions were taken into consideration. This information was collected from focus groups, interviews, questionnaires and surveys. Table 4 shows the recommendations obtained from the analysis, in order to incorporate them in the competence evaluation.

Table 4. Summary of the recommended Skills for the Performance Evaluation for each position.

Type	Item	Project manager	Chief of area	Chief of technical office
Strategic Skills	1		Focus on the client	
	2		Team work	
	3		Quality management	
	4		Systemic vision	
	5		Time management	
Specific Skills	1	Negotiation	Technical knowledge	Technical knowledge
	2	Planning and achievement of aims	Capacity of adaptation to changes	Capacity of adaptation to changes
	3	Decision making	Decision making	To be able to listen
	4	Leadership and motivation	Leadership and motivation	Resolution of problems
	5	Delegation	Delegation	Method and order
	6	Communicative capacity	Communicative capacity	

CONCLUSIONS AND RECOMENDATIONS

This research found that the current practices of personnel performance evaluation do not incorporate all the elements that professionals as well as managers would like to have. Both state that performance evaluation must contain project objectives and skills results as factors to be considered. This study identifies, incorporate and propose a way in which they can be implemented in an evaluation system.

The elements to be evaluated must be defined early in the organization order to obtain a powerful tool for performance evaluation of on site professionals. Managers and on site professionals requirements must be understood and incorporated in the evaluation methodology.

Skills selected for evaluation in this research were defined and discussed with the on site professionals and managers of specific companies. Likewise, these companies have their own culture. As a recommendation, if any organization wants to create a tool for the performance evaluation, it must develop its own process to define skills and management goals.

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Labour Market Information and Strengthening Institutional Capacity – The Canadian Experience

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Abstract
This paper describes the current environment of the construction sector in Canada. It presents for consideration the Canadian approach of acting on human resource information to build and maintain capacity in the construction sector.

Of focus is the Canadian Construction Sector Council and the impact their labour market information program is having on construction companies and buyers of construction services.

INTRODUCTION

> The "Labour Market" is used to refer to the interactions between those in need of labour and those who can supply labour. The labour market is in a constant state of change as it responds to the needs of employers who in turn respond to influences in the wider environment.
>
> …Cambridge Training and Development Ltd., *LMI Matters! Understanding Labour Market Information* (Nottingham: The Department for Education and Skills, 2004), p.5.

Canada is committed to the concept that a skilled and professional workforce is essential to developing and strengthening institutional capacity in Construction. This paper describes how the Construction Sector Council, the acknowledged lead in matters related to human resource capacity building for the Canadian construction industry is providing access to the latest, sector specific labour market information and analysis.

The paper concludes that by providing a neutral "clearing house" the Construction Sector Council provides an effective forecasting tool for use when scheduling work projects and production cycles; a tool that gives the ability to anticipate and consider current and projected labour demands against current and expected labour supplies; a tool that helps minimize risk and reduce project costs; and finally, to identify necessary and effective training programs that provide the industry with the human resources they need – when they need them.

THE CANADIAN CONSTRUCTION SECTOR

The Construction Sector in Canada employs close to 1 million men and women and produces $123 billion in goods and services.[1]

Our homes, offices and schools; the bridges, roads and sidewalks that we use; the factories that produce food and motor vehicles: all were built and put in place by the men and women who work in the construction industry. By providing infrastructure and employment, the industry is essential to the progress of the Canadian economy.

Statistical highlights:[2]

- One out of 17 workers employed in Canada earns a living in the construction industry
- There are over 260,000 firms in the construction industry: over 65,000 in residential construction and 150,000 in trade contracting industry
- Though the industry stands out as one of the major employers of workers, the size of the average construction firm is quite small. In the residential sector, nearly 90% of firms have less than 5 employees. In the non-residential sector, almost 70% of the firms have 5 employees or less
- Construction represents approximately 12% of Canadian annual GDP
- The annual GDP growth rate in 2004 was 3.2% for all industries, and 4.2% for construction
- While total employment in Canada grew at a rate of 1.8% in 2004, construction employment had a solid growth rate of 5%, with respect to 2003
- The average age of a construction worker in May 2001 was 41 years old

MEETING THE CHALLENGE

The Canadian construction industry, like many others, faces a number of human resource challenges. These include:[3]

- The cyclical (boom-and-bust) nature of the sector
- An aging workforce
- The difficulty of attracting youth to careers in the construction trades
- Barriers to labour mobility
- Training of workers to effectively assume supervisory roles

The Canadian government has taken a Sector approach to addressing human resource challenges. In Canada, Sector Councils bring together representatives from business, labour, education and other professional groups in a neutral forum in order to comprehensively and cooperatively analyze and address sector-wide human resource issues.

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[1] Construction Sector Council Website, http://www.csc-ca.org/english/industry.html
[2] Construction Sector Council Website, http://www.csc-ca.org/english/industry.html
Statistics Canada CANSIM database, http://cansim2.statcan.ca/, table 026-0008, June 17th, 2005
Statistics Canada CANSIM database, http://cansim2.statcan.ca/, table 379-0017, June 17th, 2005
Statistics Canada CANSIM database, http://cansim2.statcan.ca/, table 379-0020, June 17th, 2005
Statistics Canada CANSIM database, http://cansim2.statcan.ca/, table 282-0008, June 17th, 2005
[3] Conference Board of Canada, Insights You Can Count On – Case Study September 2005

Sector Councils focus the attention and commitment of industry partners to take action by developing human resources solutions that are specific to their sector or industry. By acting as a bridge between firms, and permitting collaboration and collective action on skills issues, sector councils promote economies of scale in addressing human resources challenges, which benefits all industry partners. The Government of Canada supports these initiatives as a facilitator.[4]

The Sector approach is an important platform for industry to engage the learning system on a national level, ensuring that the skills being developed are responsive and relevant to the needs of employers.

CONSTRUCTION SECTOR COUNCIL

In 2001 the Construction Sector Council, a national organization committed to the development of a highly skilled workforce that will support the current and future needs of the construction industry in Canada was created. Financed by both government and industry, the Construction Sector Council is a partnership between labour and business, governments and education. The Construction Sector Council has identified four key priorities:

Labour Market Information – The construction industry faces many challenges trying to ensure that there are enough skilled workers to meet the industry’s future needs. Where is construction activity growing? Where will we find tomorrow’s workforce? What skills will they need? Are there programs in place to develop these skills? How do the requirements differ at the local, provincial/territorial, regional, national and global levels?

To help answer these questions and to meet these challenges, the Construction Sector Council is working to create a construction Labour Market Information Program. The program’s objective is to ensure that people involved in the construction industry have access to the right information at the right time. The program makes key information and analysis available to employers in order to help deal with skills shortages and production cycles, forecasting labour force requirements, and assessing and developing training needs.

Technology at Work – The Construction Sector Council’s goal is to harness technology and make it work for the industry. The Council has three programs underway: a computer-based safety training program for pipeline construction discipline; an e-learning Gold Seal National Certification Program[5] on communications, negotiation and conflict resolution; project management and construction law for construction managers, superintendents and estimators.

Career Awareness Programs – The Construction Sector Council is committed to developing a highly-skilled construction workforce. The Career Awareness Programs are designed to improve the image of the construction industry and encourage young people to consider a career in construction.

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[4] Human Resources and Skills Development Canada, Sector Council Program – Partnerships at work

[5] The Canadian Construction Association Gold Seal Certification Program is a national certification program for construction Project Managers, Superintendents and Estimators. Certification is based on the candidate's education, experience and their ability to satisfy the rigorous standards of the Program. This may mean the successful completion of a Gold Seal exam. The Gold Seal Certificate was developed by the industry for the industry and is a voluntary certification program for the individual.

Standards and Skills Development – Standards and skills development are at the core of identifying and addressing the current and future human resources needs of the Canadian construction industry. Work in these areas will help create new opportunities for long-term sustainable employment and continuing job creation. Standards and skills development programs currently underway or under development include: operating engineers national occupational standards; certification and accreditation for home inspectors and building officials, essential skills; and an impact study on carpenters' standards.

The Construction Sector Council is the acknowledged lead in matters related to human resource capacity building and works in close partnership with organizations representing labour and business, education and research, and government. These partnerships include:

Construction Safety Associations – that are resident in each of the Canadian provinces. One example would be the Construction Safety Association of Manitoba which was initiated by the Winnipeg Construction Association in 1989, and has a mandate to design and implement a safety program for the construction industry. The objectives of this organization are to:

- Provide information regarding accident prevention methods and changes to health and safety regulations
- Develop training programs to enable contractors to meet their legislated responsibilities
- Provide guidance with respect to establishing comprehensive safety programs tailored to meet the needs of individual companies both large and small

The Construction Safety Association of Manitoba is a non-profit organization financed entirely by Manitoba contractors through a surcharge on a small percent of their assessment premiums collected by the Workers Compensation Board.

Skills Canada – a national, not-for-profit organization, which works with employers, educators, labour groups and governments to reposition trade and technical careers as an attractive career option for Canadian youth. Their mandate is to look for ways to guide students toward the professional opportunities available in skilled trade and technology fields.

Canadian Council of Directors of Apprenticeship – an organization comprised of provincial and territorial directors of apprenticeship, and representatives from Human Resources and Skills Development Canada. This organization is responsible for the management of the Inter-provincial Standards ''Red Seal'' Program and works with industry in the development of a skilled labour force.

The Inter-provincial Standards "Red Seal'' Program – that has been established to provide greater mobility across Canada for skilled workers. Through the program, both apprentices who have completed their training and certified journeypersons, are able to obtain a "Red Seal" endorsement on their qualification certificates by successfully completing an inter-provincial examination.

Canadian Construction Association – The Canadian Construction Association represents the interests of the non-residential sector of an industry. The objectives of the Association are to develop and promote approved standard tendering and contractual practices and procedures with the design professions and with owners; promote harmonious working relationships among its members for the benefit of the industry as a whole; provide opportunities for the exchange of opinion and coordination of efforts among its members; and expand the construction market.

Aboriginal Human Resources Development Council of Canada – is a part of the Canadian Sector Council approach and has a mission is to see full participation of Aboriginal people in Canadian labour markets. Through unique partnerships with corporate, educational, government and aboriginal leaders, the Council pioneers new ways to increase skills and training opportunities for Aboriginal people.

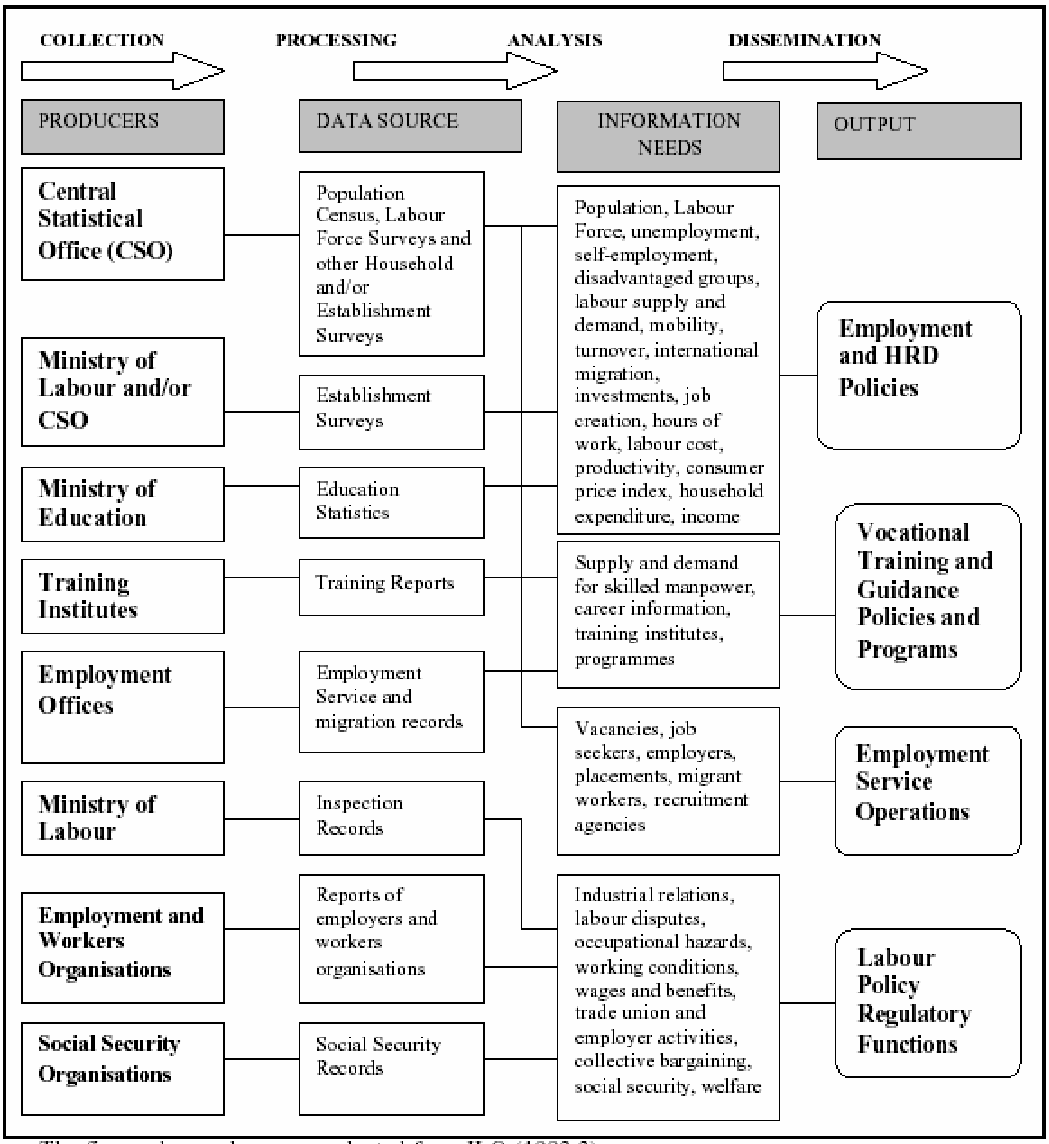
Association of Canadian Community Colleges – represents over 150 community colleges, institutes of technology, cégeps and university colleges with over 900 locations across Canada

The Department of Human Resources and Skills Development Canada – is a Canadian federal department and works to improve the standard of living and the quality of life of all Canadians by promoting a highly skilled and mobile workforce as well as an efficient and inclusive labour market.

Industry Canada – is a Canadian federal department and works to help build a dynamic and innovative economy where all Canadians have the opportunity to benefit from more and better-paying jobs, stronger business growth, and a marketplace that is fair, efficient and competitive.

LABOUR MARKET INFORMATION SYSTEMS

Figure 1: Generation and Flow of Labour Market Information.



The figure shown above was adapted from ILO (1992:3).

"A useful information system is one that provides the job seeker as well as the policy maker with information to assess the state of the labour market from their respective perspectives…it takes labour market statistics and other relevant facts and information, and converts them into answers to questions posed by decision makers at all levels of the labour market."[6]

[6] Chernyshev I (1998: 476)

Some of the challenges that impede a labour market system are[7]:

- Limited capacity and instruments to effectively, regularly and in a timely way collect, analyse, and disseminate relevant and reliable labour market information
- Inability to combine information from various sources and particularly the failure to incorporate data collection exercises on the informal economy into the national framework
- Inadequate resources for statistical programmes and other activities aimed at generating LMI
- Inability to co-ordinate efforts or share information
- Inability of users to specify needs and to translate these needs to producers of LMI
- Information collected is not further analysed to make it relevant
- Weak structural mechanisms to link policy practice with movements in the labour market
- Lack of a clear mandate on who should do what
- Lack of a culture of information use
- Inadequate balance between qualitative and quantitative labour market information
- Lack of assessment of the relevance and usefulness of information to various users, particularly those outside government ministries and agencies

THE CONSTRUCTION SECTOR COUNCIL SECTOR COUNCIL'S LABOUR MARKET INFORMATION PROGRAM AND ITS BENEFIT TO THE CONSTRUCTION SECTOR

A recent case study done by the Conference Board of Canada of the Construction Sector Council's Labour Market Program gave them "top marks" for their initiatives and efforts to meet these challenges.

The Construction Sector Council's Labour Market Program has been designed to be inclusive and collaborative. The Program gives a practical perspective of both the supply and the demand sides of the construction sector. The Program significantly enhances the way companies schedule projects, make project decisions based on an assessment of labour-supply risk, identify sources of labour from across the country, identify training requirements, and influence the way supply-side solutions like apprenticeship training programs are developed and implemented.[8]

To this end, the Construction Sector Council has created three working groups:

The National Owners' Forum – is a national group who represent those who buy construction product. The Forum engages in the development and use of labour market information as a tool to facilitate human resource and project planning. It provides a venue to:

- Identify and discuss priority human resource issues
- Receive and share labour market information
- Recommend initiatives that the Construction Sector Council Labour Market Information Program should undertake

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[7] Nicholas Mangozho, International Labour Office, Geneva. *"Current practices in Labour Market Information systems development for human resource planning for developed, developing and transitioning economies."*
[8] From an update on the Construction Sector Council's Labour Market Information Program given by George Gritzotis to the National Owners' Forum on April 7, 2005.

- Provide advice and guidance to the Construction Sector Council on their Labour Market Information Program

Labour Market Information Regional Networks – are groups from across Canada that work with the Construction Sector Council to ensure that their work reflects regional reality. Approximately 100 organizations make up seven networks, demonstrating the importance that is placed on the Construction Sector Council Labour Market Information Program. These groups provide:

- Local intelligence on labour market issues
- Collect regional data
- Validate Construction Sector Council Labour Market Information Program outputs.

Industry Focus Groups – hosted by the Construction Sector Council and used to define the industry supply-side information requirements. These focus groups are used to:

- Introduce Labour Market Information Program plans
- Consult with industry on design
- Achieve buy-in and support for the program

AN INDUSTRY PROFILE

Over the past three years, the Construction Sector Council has commissioned a number of research projects to better understand the supply of labour available in the construction industry:[9]

- Future Supplies for Canada's Construction Industry
- Emerging Trends in Management, Supervision and Mentoring in the Construction Industry
- Training Canada's Construction Workforce
- Meeting the Industry's Needs
- Impact of Technology on the Construction Labour Market

The findings from these reports, along with data from existing sources, have built a framework that provides labour supply information to interested stakeholders on an ongoing basis. Key elements of the framework include:

- *Labour Force Profiles* for up to 30 occupations, including trades, managers and related groups, providing information on age, education, occupation, mobility, training, income, immigrant status, gender, labour force activity and other relevant categories
- *Labour Mobility Profiles* to better understand worker migration patterns, within Canada, the United States and other countries. These will identify potential local labour market barriers to internal and external migration

The Construction Sector Council has overseen the development and launch of a forecasting tool that predicts labour market requirements for the industry. This is a tool that can help to answer the questions of why, where and when, contributing to on-time and on-budget projects, thus beginning to address the challenges mentioned earlier that impede a labour market system.

[9] These reports are available from the Construction Sector Council

In collaboration, the Construction Sector Council has implemented a pilot project designed to collect information on major construction projects. This pilot project will facilitate more involvement by participants in the labour market information process, improving the reliability of information for large scale projects. The success of this project and others like it is dependant upon participation. A web-based "Labour Market Link" has been established that, through ease of use and protection of confidential information makes the input and maintenance of data on current and proposed projects practical. In return, participants are able to retrieve timely information that is updated regularly.

IMPACT ON THE INDUSTRY

> A useful labour market information system – one that is rigorous, accurate and representative of the industry – is nothing short of a business lifeline to many companies.
>
> … Conference Board of Canada, Insights You Can Count On – Case Study September 2005

Project Planning

Sound, responsive and reliable labour market information is essential to the construction sector planning process. This information is relevant to project design, project development and project execution. The forecasts of short, medium and long term labour supplies for any given trade is matched against demand estimates, enabling informed decision on investment in projects.

Part of risk mitigation on any project, whether it is large or small, must be sound knowledge that people with the right skills will be available to complete the work on time and on budget.

All of the companies interviewed for the recent case study completed by the Conference Board of Canada on the Construction Sector Council Labour Market Information Program indicated that using the information was a "critical component" of their decision making process. This information is a critical component of the bigger planning and development strategy.

Training and Apprenticeship

Labour market information, translated into career awareness information can identify those trades and skills that are and will be in high demand. Both current and future workers can use this information in their career planning and as they make their education and training choices.

Construction companies acknowledge that when skilled labour is unavailable it is necessary to turn to less experienced, lower-skilled or un-skilled labour. This increased the potential for accidents, which means a loss of productivity. They require the right people, with the right skills, at the right time.

Labour market information allows training organizations and learning institutions to respond to both quality and quantity requirements for the sector. Based on labour market information decisions are made on curricula, program design, and trades and apprenticeship models.

Apprenticeship training programs are setting their targets based on labour market information. For example, an apprentice career awareness program could make a concentrated effort in a particular area, based on a projected shortage, potentially alleviating the shortage.

The Association of Canadian Community Colleges, a partner of the Construction Sector Council, works collaboratively with the industry. They have a Construction Affinity Group with 40 colleges involved, which brings together individual colleges with an interest in Construction related studies to discuss common interests, ideas, challenges, best practise, effective programs, advocacy concerns and recent developments.

The Association of Canadian Community Colleges also has an Apprenticeship Affinity Group with 47 participating colleges and satellite campuses.

ESSENTIAL/EMPLOYABILITY SKILLS

In Canada, another important product of sound labour market information is the Essential Skills Initiative and the Employability Skills initiative. These two initiatives are similar in that they both contain a set of skills considered necessary for employees to function well in the workplace.

Based on labour market information and research conducted by the Canadian Government and other national and international agencies the skills have been identified through consultation with employees and employers. In both initiatives the skills referred to are not the technical skills required by particular occupations but rather skills that can be applied in all occupations.

More and more Canadian companies are acknowledging the need for developing these types of skills in their employees, recognizing that many high school, college and university graduates lack the Essential Skills or Employability Skills required. For example, an engineer might have exceptional technical skills but may lack the communication skills necessary to convey information to building contractors. The level of individuals Essential Skills or Employability Skills is not dependent upon an individual's level of education. People with little formal schooling can acquire sophisticated Essential Skills or Employability Skills outside of school through life experience, personal initiative, or in the workplace. It is also important to note that there are varying levels of complexity for skill set ranging from lowest to highest. For example, a person possesses a certain degree of literacy; he or she is not simply literate or illiterate.

The Canadian Construction Sector Council have been active in helping the industry to realize that ensuring their employees have the right workplace skills is sound investment. Companies need to keep pace with change in order to remain competitive. Employers who continually invest in their employees, especially in the area of workplace skills that impact every part of their day to day operations, are better equipped to respond. Increased profits and other bottom line benefits can be reported if employees are equipped with the basic skills that enable them to work more effectively.

Some of the specific bottom line improvement areas that have been noted are:[10]

- Improved employee morale/self esteem
- Increased quality of work
- Improved capacity to solve problems

[10] Conference Board Research Report: Turning Skills into Profit. 1247-99-RR

- Better team performance
- Improved capacity to cope with change in the workplace
- Improved capacity to use new technology
- More employees participating in job-specific training
- Higher success rate in promoting employees with the organization
- Improved effectiveness of supervision
- Increased capacity to handle on-the-job training
- Improved labour-management relations
- Increased output of products and services
- Higher success rate in transferring employees with in the organization
- Improved results in job specific training
- Reduced time per task
- Reduced error rate
- Better health and safety records
- Reduced waste in production of products and services
- Increased customer retention
- Increased employee retention
- Reduced absenteeism

Essential Skills Model

The Essential Skills Model has been developed by the Government of Canada[11] and is considered to be the descriptor of enabling skills that:
- Help people perform the tasks required by their occupation and other activities of daily life
- Provide people with a foundation to learn other skills
- Enhance people's ability to adapt to change.

There are nine Essential Skills:
- Reading Text
- Document Use
- Numeracy
- Writing
- Oral Communication
- Working with Others
- Continuous Learning
- Thinking Skills
- Computer Use

A database has been created that includes the full range of skill usage, from basic to complex as well as a series of ***Essential Skill Profiles*** that describe the frequency and complexity of the use of essential skills in different occupational groups. An Essential Skills Profile describes how each essential skill is actually used by workers in an occupational group. For each essential skill, a Profile generally contains:
- Complexity ratings that indicate the level of difficulty of the tasks related to that skill.
- Examples that illustrate how that skill is actually used.

[11] In 1994, Human Resources and Skills Development Canada launched a national research study, the Essential Skills Research Project (ESRP), to examine how the essential skills were used in various jobs. More than 3,000 interviews have now been conducted across Canada with people working in some 180 occupations.

- A standardized description of how that skill is used so readers may make comparisons between occupations or aggregate information across occupations.

Employability Skills Model

The Employability Skills Model was created by the Conference Board of Canada[12] and includes those skills that are considered to be the critical skills you need in the workplace. Employability Skills include communication, problem solving, positive attitudes and behaviours, adaptability, working with others, and science, technology and mathematics skills.

The Model can be separated into three areas:

- ***Fundamental skills*** or those skills that are needed as a base for further development. These skills include communication, managing information, using numbers, and thinking and solving problems
- ***Personal Management skills*** or those personal skills, attitudes and behaviours that drive personal potential for growth. These skills include demonstration of positive attitudes and behaviours, responsibility, adaptability, continuous learning , and work safety
- ***Teamwork skills*** or those skills and attitudes needed to contribute productively. These skills include working with others and participating in projects and tasks.

LESSONS LEARNED

The Construction Sector Council and other members of the Sector Council Program (representing approximately 30 Sectors of Canadian industry) have identified the following important circumstances for success of a labour market information program:

- The program must be based on mutual benefit and done in cooperation with other initiatives
- Success is dependant on an inclusive and comprehensive approach
- Forecasts must be as accurate, credible and meaningful as possible
- Customising labour market information assessments is important
- Offering analysis that speaks to the needs of different users is important
- Comprehensive information that appeals to a wide range of users is a prerequisite
- A neutral and national clearing house must be established
- Easy to use web-based applications must be implemented
- Attention to developing and increasing institutional and political support for labour market information must be done on an ongoing basis

[12] Employability Skills 2000+ (Employability Skills Model) was created by members of the Conference Board of Canada's Employability Skills Forum and the Business and Education Forum on Science, Technology and Mathematics

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Competition Policy and the Construction Industry in Developing Countries

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Abstract
The trend towards globalisation of markets is based on liberalization of the terms of trade. In the Free Trade Area of the Americas, competition policy is being promoted as a means of preserving and promoting competition, both by enforcing competition law to prevent firms from applying what are called 'restrictive business practices', and by influencing governments to adopt policies promoting competition. The World Trade Organisation is also discussing the possible adoption of a multilateral framework on competition. The Developing Countries are already skeptical about the intentions and policies of the WTO, so it is important that they are involved in the formulation of any such competition policy framework. For it to be supported, the DCs must be convinced that it can benefit those countries and better enable them to meet their challenges. These issues are examined in the context of the role of construction in the world economy, and the dynamics of its relationships with indicators of development, particularly in the context of the developing world where a large proportion of construction occurs outside the market economy. It is found that there are serious reservations within the industry in the Caribbean region.

Keywords
Competition, policy, developing country, trade liberalisation, collusion

INTRODUCTION

Developing countries are generally considered to have less competitive markets than the more developed countries. This is felt to be a bad thing because it deprives the consumers of the choice and the economic efficiency that competition is expected to bring. This has resulted in the past decade or so, in attempts to promote higher levels of competition in the developing world. To achieve this, the main focus has been the introduction of a 'competition policy' that will help create, preserve and promote open markets and free competition in those countries. The policy itself would involve both the introduction and enforcement of laws against anti-competitive 'restrictive business practices' (RBPs) by domestic firms in those countries, and also the implementation of other measures (e.g. fiscal or legislative) to promote competitiveness. The specific policy measures adopted by any country will obviously focus on the issues that affect and are relevant to that country, and that are within the limits imposed by the World Trade Organisation (WTO), the General Agreement on Tariffs and Trade (GATT) and the General Agreement on Trade in Services (GATS), as well, where relevant, as the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), and the

Agreement on Trade-Related Investment Measures (TRIMS) (WTO, 2003). The construction sector officially falls under the provisions of the GATS and is thus treated as a service industry[1].

The belief that improved competitiveness would lead to improved economic performance led the international financial agencies, like the International Monetary Fund (IMF), to insist that a country falling into financial difficulties had to adopt a Structural Adjustment Programme (SAP). These SAPs were designed to promote competition by a series of policies including opening markets to external trade, reducing the size of government, the privatization of public businesses, and allowing the local currency to float. Unfortunately, the experience with these measures has been patchy at best (Giridharadas, 2005). They have not only tended to be divisive and cause social unrest[2] but they have also largely failed to stimulate local competition and the economic benefits of privatization have been questionable (Global Exchange, 2003).

Competition

There are two different ways of looking at competition[3], which can be characterized as 'structural' and 'behavioural'. The *structural* approach views competition in terms of a market equilibrium position with the number of firms in the market as being a critical parameter, and with perfect competition (lots of suppliers) at one end of the scale and monopoly (single supplier) at the other. The *behavioural* view sees competition in terms of business rivalry and response (Porter, 1980).

In the former 'structural' school, competition is a process and is a measure of market concentration and the dominance of individual firms. Competition is the mechanism that forces the least efficient firms to leave the market, and that attracts in more efficient newcomers with the prospect of profits to be made. It is important that it is possible for firms to enter and leave a competitive market largely unhindered by barriers created by government. The motivation for firms to keep up-to-date is provided by the threat of competition from firms entering the market with new, more efficient technologies. The more firms in the market the more likely it is to be competitive.

In the 'behavioural' school, competition is viewed as a function of firms' behaviour. Porter (1980) characterizes competitiveness as a function of strategic management, using the term 'rivalry' to denote competition, and then focusing on the five forces that influence the strength of rivalry in the market. These five forces are supplier power, threat of substitutes, degree of rivalry, buyer power and barriers to entry. Although the number of firms does influence the intensity of rivalry, it is only one amongst many factors that are important in determining the firm's response (behaviour) to market conditions (competition).

[1] However, as Francis (1997) notes "according to the definition of goods and services in the United Nations Systems of National Accounts 1993, this sector represents one of the goods producing sectors of the economy. Goods are physical objects for which a demand exists, over which ownership rights can be established and whose ownership can be transferred from one institution to another by engaging in transactions on the market. The separation of the production of a good from its subsequent sale and resale is an economically significant characteristic of a good that is not shared by a service."
[2] For example, the attempted coup in Trinidad & Tobago occurred shortly after the imposition of an SAP by the IMF in the early 1990s.
[3] Henricsson *et al* (2004) do present a view that crosses boundaries in that they define competitiveness as "the ability to, in the long term, satisfy the sophisticated demands of companies, clients and society respectively and simultaneously, while acting under free trade and fair market conditions, exposed to an international market environment." This is more structural than behavioural but does not fit comfortably in either camp.

Both models of competitiveness recognize that the market is also conditioned by its socio-economic environment. Hence, the state of the country's physical infrastructure, the sophistication of its financial markets, the availability of skilled manpower, the technical support for capital equipment, the legal environment, and the regulatory environment for industry and trade all affect the ability of firms to compete both locally and especially against their foreign counterparts. The frameworks discussed in Ericsson (2004) try to provide a description of competitiveness that can help provide a reasonably objective measure, and culminate in their *Construction Industry Competitiveness Hexagon*. This work leans on Porter quite heavily, and the authors accept that although it provides a good starting point for understanding the competitiveness of a construction industry, it still requires further development before it can be operationalised.

In international trade negotiations, the emphasis is on the structural view of competition, with a major focus being on opening the market to more potential competitors. As Dhanjee (2004) writes, 'The benefit – and the common aim everywhere – of competition policies is to promote economic efficiency and consumer welfare by encouraging entrepreneurial activity, market entry by new firms, and more enterprise efficiency and competitiveness.' This is an admirable aim, but it overlooks the possibility that governments in the developing countries may wish to use relatively inefficient approaches to public sector procurement. They may want to use the Keynesian strategy of a labour intensive approach – particularly for smaller scale construction projects - in order to distribute income, to promote both local and smaller firms and also possibly to decrease market 'concentration' – i.e the proportion of the market dominated by a limited number of firms. This strategy is, however, basically against the rules of the WTO, which requires markets that are open to all, on equal terms, and should not favour any firm, local or foreign, over its competitors (Moore, 2001).

The basis of the globalization of trade is the promotion of international competition in all markets, so the favoured form of competition policy is one that focuses on openness and transparency. The assumption is that any inequities created by the local technical and socio-economic environments will be insignificant or short lived, or both. In ther words, local firms that had previously operated in a protected market may be at an immediate disadvantage when exposed to open competition, but they should soon be able to sort this out and compete with the best[4]. This assumption may not be realistic, and may cause serious local dislocation before any sort of local base of effective and competitive firms can be established. This is particularly the case for the construction industry[5] which will almost certainly find itself outbid in an open market for big projects by large foreign firms. Their failure to win a big project today will act against (disqualify) them when tendering for future big projects. Table 1 gives a listing of the distribution of global construction by the type of facility, for five year periods from 1998 upto and including 2013.

[4] The logic goes that if they cannot, then they should not be in the market anyway. Good riddance.
[5] A definition of what the construction sector involves is given in Appendix 1.

Table 1. Annual percentage changes by market in global construction (in constant 1997 US$)

	1998-2003	2003-2008	2003-2013
TOTAL	1.2	2.6	2.6
Residential	2.7	1.5	1.6
Infrastructure	1.2	3.2	3.0
Non-residential Structures	-1.2	3.6	3.8
Office	-1.1	3.8	4.1
Commercial	-1.8	3.2	3.6
Institutional	-2.4	1.8	2.2
Industrial	-0.3	4.5	4.5

Source: Tulacz (2005)

The projected high growth rates in non-residential structures, offices, commercial structures and industrial buildings over the next decade or so suggests that the commentators have a fairly optimistic view of future economic growth. These structures are not particularly high-technology and so they present no serious problem to qualified design professionals or to competent contractors.

Table 2 gives a listing of the top fifteen countries in terms of the size of their expenditures on construction from 2003 upto and including estimates for 2008. There is clearly a massive and growing market and the projections indicate a clear opportunity for firms that are able to enter external markets to exploit. The fact that contarctors from China and South Korea are now active players in the international market suggests that some of the larger developing countries are able to break in and win jobs against internationally competitive bidders.

Table 2. The top 15 nations in construction spending (in US $ Bil.)

Country	2003	2004	2005	2006	2007	2008
United States	1,039.3	1,159.1	1,210.1	1,218.0	1,244.0	1,288.6
Japan	464.5	506.8	543.8	571.5	587.4	609.5
China	241.9	269.1	299.6	338.1	388.4	440.0
Germany	220.6	246.8	258.2	267.0	282.2	292.1
France	173.0	196.8	208.2	218.3	234.0	245.2
Italy	160.0	182.1	193.4	203.1	218.4	229.3
United Kingdom	151.2	177.5	183.4	190.0	201.4	210.8
Spain	144.0	165.9	178.7	189.6	204.4	215.4
Canada	105.9	123.3	132.2	141.0	151.5	160.1
Netherlands	70.0	78.5	82.6	86.4	92.5	96.9
India	65.0	73.9	78.5	84.9	92.2	100.0
Mexico	62.6	65.5	69.1	71.4	72.8	75.1
Brazil	42.3	54.3	56.7	59.4	61.4	65.3
Australia	48.5	49.3	51.3	53.8	55.9	58.7
Russia	33.9	42.3	47.0	51.5	56.2	61.0
Total (55 Countries)	3489.5	3913.5	4151.5	4335.6	4577.2	4817.7

Source: Tulacz (2005)

The policy implications, of course, are different for large, heavily-populated developing countries and for small island developing states (SIDS). The large, populous developing countries have a competitive advantage in terms of their relatively low-cost labour force, and some (e.g. China, India and S.Korea) are currently actively and successfully competing in international markets for construction projects,. The SIDS do not have the same advantage, and, in fact, often face a shortage rather than a surplus of manpower. Whilst the large developing countries may benefit from liberalised markets, the benefits of open markets in construction in the SIDS are debatable.

COMPETITION POLICY

Competition policy is intended to address the issues involved in creating competitive local as well as external markets. In either case, there are three basic issues that need to be considered when formulating policy, and they are the market entry and exit conditions, the potential for collusion between firms, and market concentration.

Entry and Exit

A market is considered competitive and efficient if firms can enter and exit freely. Barriers to either can result from governmental, structural or commercial sources. Governmental barriers take the form of regulations and restrictions of trade, controlled allocation of resources and price restrictions. Structural barriers may be financial, legal or geographical, and commercial barriers include things like predatory pricing, proprietary technology and the cost of establishing a name through high-cost advertising (World Bank, 1991, 2001). Each of these potential barriers needs a different focus, and has different implications for internal and external markets.

Collusion

Collusion is generally seen to affect competition by the existence of agreements amongst suppliers and contractors to fix prices, either through general agreements on price levels or through arrangements on specific contracts. Both affect the customer adversely, and distort the workings of the market.

Another form of collusion occurs through 'interlocking directorships', where individuals may be on the boards of a number of firms, most critically those that may be in competition with one another, and consequently have inside knowledge of their business and their policies. This is especially a problem in the SIDS, which typically have limited manpower and a consequent shortage of managerial resources and a concentration of ownership. Collusion is, however, difficult to detect and prove, and it may be difficult to prevent.

Concentration

Because it is easier for a small number of firms to reach a price-fixing agreement, concerns about collusion are strongest when there is a limited number of firms in the industry, i.e. what is called 'concentration'. Concentration levels are typically higher in developing countries than in industrialized countries, with a few large firms dominant in many sectors. This is often the case in construction as the limited number of large projects in the local market restricts the number of large firms that can be supported. Competition policy in developing countries must address the difficult issue of how many firms can be supported and how many are needed to 'dilute' market concentration sufficiently to prevent potential collusion.

Governments must, of course, pay attention to their constituencies, and decide how to balance the immediacy of domestic needs against the international pressure to open their internal markets to external competition. The deciding factors are the roles politics, bureaucracy and economics play in the design of their competition policy. In the construction sector, the main issues in the design of such policy include local unemployment levels, the creation and survival of local firms, registration of professionals, nationality and residency requirements, restrictions on the movement of people, restrictions on foreign firms including the need for local participation, and may even include the need to make the distribution of wealth more equitable and to help alleviate poverty (Stiglitz, 2002).

INTERNATIONALLY COMPETITIVE BIDDING

Most countries have a construction sector that involves a small number of large firms, a moderate number of medium-sized firms, and a large number of small firms. These small firms often act as specialist sub-contractors or their operations are restricted to a limited geographical area. Projects that are let on the basis of internationally competitive bidding are generally large-scale infrastructure or urban redevelopment, or resource recovery or processing projects. The occasional highly technical, large developments like petrochemical plants are generally dealt with on a 'turnkey' basis by transnational specialist contractors – these can rarely be competitively bid because of proprietary or technical restrictions. However, the other large infrastructure or urban renewal projects, like a water pipeline or road extension, typically have little technical complexity involved. Provided the project size was within their financial and human resource scope, such projects could easily be handled by local firms, however, they rarely are, for a variety of reasons (e.g. high prequalification criteria) Because of the type of work involved in such projects, they are normally implemented, in the terminology of trade negotiations, by the 'commercial presence' of a foreign firm. If the project is small enough it may be handled through the 'presence of natural persons'. The 'cross-border supply' of construction services is limited to design work and other services that can be supplied electronically.

Companies from smaller developing countries in particular that have tried to pursue such large international projects often find it difficult locally to access financing, bonding, performance guarantees, insurance and legal services for offshore projects. Similarly, Export Credit Guarantees (ECA Watch, 2003) are available in many developed countries but not in developing countries. These reasons make it clear that the playing field is not 'level'; it is tilted heavily in favour of larger firms from the developed countries. It is not clear that any form of competition policy could address these inequalities in a way that would be acceptable to the WTO.

CONCLUSION

In developing countries in particular, government procurement plays an important role in the demand facing the construction sector. The openness and lack of restrictions required by the international trade arrangements limits the scope for policy and restricts the controls that governments can impose even in their domestic markets and on public sector expenditures. This does not make a competition policy pointless, it actually makes it all the more important.

Much of the focus of trade negotiations is on the removal of traditional barriers[6] to market entry and exit. This is supposed to allow firms to access markets anywhere in the world, but it is unlikely to be sufficient to enable firms from the developing countries to extend their operations abroad. The problem of resource shortages, and the inadequacy of financial and legal support structures available in their home countries will continue to frustrate their ambitions. The full impact of the barriers and

[6] Like tariffs, for example

support structures that do exist in the developing countries is not known, however, so there remains a need for research to clarify these issues.

It has been suggested that competition is handicapped by the effects of collusion amongst firms and that there is greater scope for collusion in developing countries simply on the basis of the number of firms of a certain size that exist (Cook, 2002). Research is needed to substantiate this, although it would be very difficult to obtain substantive evidence for what, after all may be illegal activity.

The introduction of privatisation programmes has involved selling off public assets on a grand scale, or at least changing their structuure of ownership to be much more biased towards the private sector. There is much disagreement on the benefits of this exercise, but it remains an important element of programmes aimed at liberalising trade and enhancing competition. There is need for an objective analysis of the benefits of privatisation, particularly for smaller deeveloping countries.

Finally, as Dhanjee indicates, “competition policy has the potential to bring many benefits to the Caribbean, but this potential is unlikely to be fully realized unless competition policy is applied in a way which: (a) fully takes into account relevant Caribbean conditions and social preferences, as well as external experiences, as illuminated by thorough research; (b) appropriately factors in efficiency and competitiveness considerations; and (c) both avoids straying too far from social consensus and promotes an evolution of this consensus, by engaging society in a project of economic transformation and development. All of these would require good data and institutional capacities – and since these cannot be obtained until sufficient public support and resources have been acquired, a phased approach towards bringing competition laws into full force would be desirable”.

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APPENDIX I

Definition of Construction

The following is the definition of what is 'normally' contained within the concept of construction, and which may be included in the statistics on the sector:

General construction work for buildings: includes construction work (including new work, additions, alterations and renovation work) for all types of buildings, residential or non-residential, whether privately or publicly owned. General construction work for civil engineering: covers construction work for structures other than buildings such as highways and streets, railways an airfield runways, bridges and tunnels, waterways and harbours, dams, pipelines, communication and power lines, mining and manufacturing plants and stadia and sports grounds. Installation and assembly work: includes such activities as the assembly and erection of prefabricated constructions, installation work for hating and air conditioning, water plumbing, gas fitting, electrical wiring, fire alarm construction, insulation, fencing and lift construction. Building completion and finishing work: this item covers special trade construction work for the completion and finishing of buildings such as glazing, painting, floor and wall tiling, carpeting, carpentry, interior fitting and decoration, ornamentation fitting. Other: includes pre-erection work at construction sites, as well as special trade construction work such as foundation work, water well drilling, roofing, concrete work, steel bending and erection, and masonry work. It also covers renting services related to equipment for construction or demolition of buildings or civil engineering works, with operator.

In Trinidad & Tobago, the construction sector is limited to: building construction & repair (residential, commercial, public, industrial etc.); civil engineering – roads & bridges; electrical installation and air conditioning; plumbing installation; painting & decorating; general construction contracting; other specialized trade contractors; construction equipment rental; quarries.

Management and technology for quality and sustainability of masonry components in Brasilia's market

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Abstract
The paper's goal is the analysis of different masonry components considering some aspects like energy, quality and sustainability, waste and management. The components considered in this study are ceramic block and concrete block. The criteria for the quality and sustainability analyses considered the impact of production with an emphasis on the energetic content, and aspects of materials' management and waste, observed in building construction sites in Brasilia. The methodology used is based on surveying some blocks' factories to obtain data about the energetic content of components and also data on the waste in Brasilia's sites. Between ceramic block and concrete block, we conclude that the first one requires more energy in the process in the researched area. Besides that negative point, ceramic industry is responsible in Brazil to employ lots of workers, so other studies must be done in order to analyze this importance. The results provide recommendations for the proper selection of masonry components when using ceramic blocks or concrete blocks, as well as the data on the masonry quality and sustainability, considering the whole production process, from the component to the waste generated at the end of the process.

Keywords
Management, quality and sustainability, masonry, energetic content and recycling

INTRODUCTION AND OBJECTIVES

Environmental sustainability is a recent subject that is being discussed around the entire world nowadays. The global warming is one of the bad effects we are watching which is caused by the burning of gas, oil and coal, cutting down of rain forests and many other actions of mankind.

Searching renewable sources to produce energy and reducing energy consumption in building construction is one of the priorities nowadays. It means we have to use the less possible energy and raw materials to build, considering all the steps of the process.

The concern about the negative impact of man's intervention on the environment is increasing and the legal and market requirements led to development of environmental management tools, looking for the best control of the building's process production (MASTELLA et al, 2001).

The building construction cycle is complex to analyze and it includes from the extraction of raw material to the building demolition, when the building's useful life is finished.

This paper’s focus is the masonry due to its importance in building, the amount of energy used during the production of materials and components, and the waste in sites during the building construction. Concerning masonry cycle, its main steps are: raw material extraction, material and components production, masonry construction, maintenance and demolition at the end of the useful life. We can consider that there are energy comes from fuels (gas, oil, fire, diesel, etc.) and the human effort in all the steps, but the biggest amount of them is required in the production of components. The waste occurs during the process and at the end of it, too.

The management of the masonry building is done to achieve the process optimization. Planning and choosing proper and available raw material, using the sustainable fuels to produce materials and components, controlling the production process of components, producing materials and components according to guidelines; controlling waste in the building sites, etc. are some of the required management’ activities.

The goal of this paper’s is to analyze some aspects of technology and management looking for the masonry’s quality and sustainability. The analysis was done with an emphasis on energetic contents of ceramic and concrete blocks that supplies Brasilia’s market and the waste of materials in sites using both of components.

METHODOLOGY

Let’s consider for a moment, two items of this research of this paper.

The first is the blocks production (on the blocks’ factory) and the second is the masonry construction (on the site). In the first one we obtained data about the energetic contents and in the second we made some conclusions about the waste of both components analyzed in the area studied.

Two case studies about ceramic and concrete block’s factories that supply the local market in Brasilia were researched. The criteria used in the factories choice were:

- To show interest in this research;
- To have a quality management system in progress and
- To present products according to Brazilian guidelines.

Aspects of the masonry waste and the site’s management were also analyzed in the step of the masonry’s building,

MASONRY, ENERGETIC CONSUMPTION OF THE CERAMIC AND CONCRETE BLOCKS THAT SUPPLIES THE BRASILIA’S MARKET AND WASTE IN BUILDING CONSTRUCTION SITES

3.1. Introduction

In the past, before the Christian era, people used to build with materials available from their natural environmental, such as tree trunks, twigs, straw, reeds, sods, and loam. This was a primitive way of building their houses. The Romans arrived, bringing natural stones and even clay-backed materials from far-away regions (HENDRIKS, 2000).

Factories in many places of the world started burning bricks in order to improve the quality. Besides bricks, blocks were also burned to reduce the weight of the masonry, mainly of tall buildings with structures of reinforced concrete; in this case, masonry had no structural function.

In Brazil, in years gone by, masonry was built with stone, wall-mud and sun-dried brick, deriving from Portuguese colonization and Indian native. Most of the masonry was structural. At a later stage, and after the industrialization, with the construction of tall buildings and the development of the reinforced concrete, Brazil started to use masonry without structural function; ceramic blocks and concrete blocks were manufactured for this purpose, and this lasts until today.

Data on the energetic consumption are welcome in order to analyze the best options for masonry building in the area studied. The Department of Civil and Environmental Engineering at University of Brasilia is developing some researches of quality and sustainability of masonry, including life cycle analyzes (LCA) and waste of the components. Among theses researches, we can point AZEVEDO (2005) and SPOSTO et al (2000).

3.2 – Ceramic Blocks: general aspects of the components production and energetic consumption

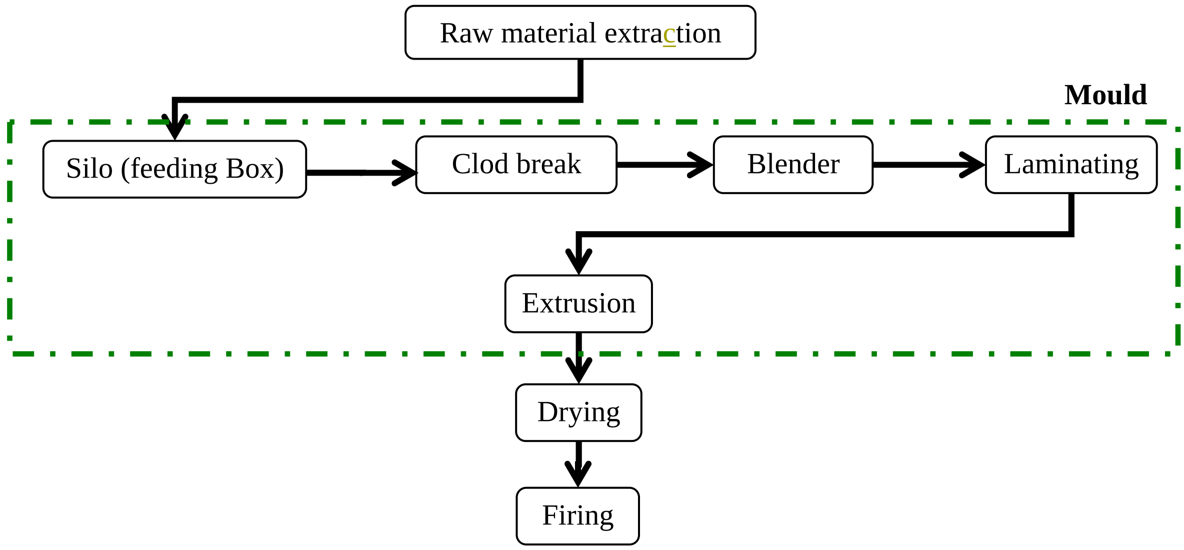
The main raw material used on ceramic blocks is clay. The size and the shape are made by extrusion. The burn is by heating in a furnace. The technology used for manufacturing is still not very developed in many places, with some exceptions of big factories in Brazil. The manufacturing process used in this sector is variable, leading to huge differences concerning the product's quality. We can see rudimentary equipments, as well as automatic equipments of production.

However, in all the cases the process consists of: silo (feeding box), break of clods, blender (the moment which water is added) and lamination.

a) After the lamination, the blend goes through the extrusion machine, which has a mould with function of giving the block's shape.
b) A conveyor does the transportation from the silo to the extrusion.
c) After that, the blocks are cut.
d) The next step is drying, since the blocks can't have much humidity before going to the furnace to burn.
e) The last step is burning.

Figure 1 shows the steps of the ceramic production.

Figure 1 – Steps of the ceramic block production



In Brazil, the fuels used to burn blocks are natural gas, firewood, industrial wood and residues. In the area studied, including state of Goiás and Distrito Federal, firewood and industrial wood are the most used fuels.

The factory studied on this paper is located in Anapólis, state of Goiás. This city is the most important block's supplier of Brasilia. The factory is implanting a quality management system in order to get the process improved and controlled. Table 1 shows the factory's characteristics about the ceramic block production.

In this case study the clay extraction is made by mechanic excavation. The energy consumption in this step concerns the fuel amount used to make the excavation. We didn't consider the fuel to transport the raw material to the factory because in this case the distance is very small, but in other cases we have to consider it.

The next step is the mould of ceramic block, which is a pre-processing, including feed box, clod break, blender, lamination and extrusion. The energy required in this steep is electricity.

Table 1. Factory's characteristics about the ceramic block production

Dimensions – width, height and length (mm)	90 x 190 x 190
Monthly production	1.000.000 (One million)
Strength compression (MPa)	2,0
Water absorption %	20
Energy source	Industrial wood and firewood
Raw material origin	Lying own
Consumption market	Material construction stores of the neighboring area and of Brasilia's

Little cars using human and electric energy make the internal transportation of the ceramic blocks.

In the drying step, they use a mixing process, which consists of natural and artificial ones, using the heat that comes by the furnace, besides the fans and suction fans. The energy required in this step is electricity. After drying, the blocks go to the burning, and in this case it is made by tunnel furnace. The energy required in this step is industrial wood or firewood and electricity. The last one is used in order to push the little cars and for the suction fans, too.

Table 2 shows us the energy consumption in the different process steps, per ton of blocks produced.

Table 2. Energy characteristics per one thousand of blocks for the tunnel kiln process

Process Step	Firewood (J/1000und.)	Diesel (J/1000 und.)	Electricity J/1000 und.)
Raw material Extraction	-	8773,44	-
Moulding	-	-	-
Drying	-	-	$389{,}0 \times 10^6$
Firing (tunnel kiln)	$3{,}528 \times 10^9$	-	-

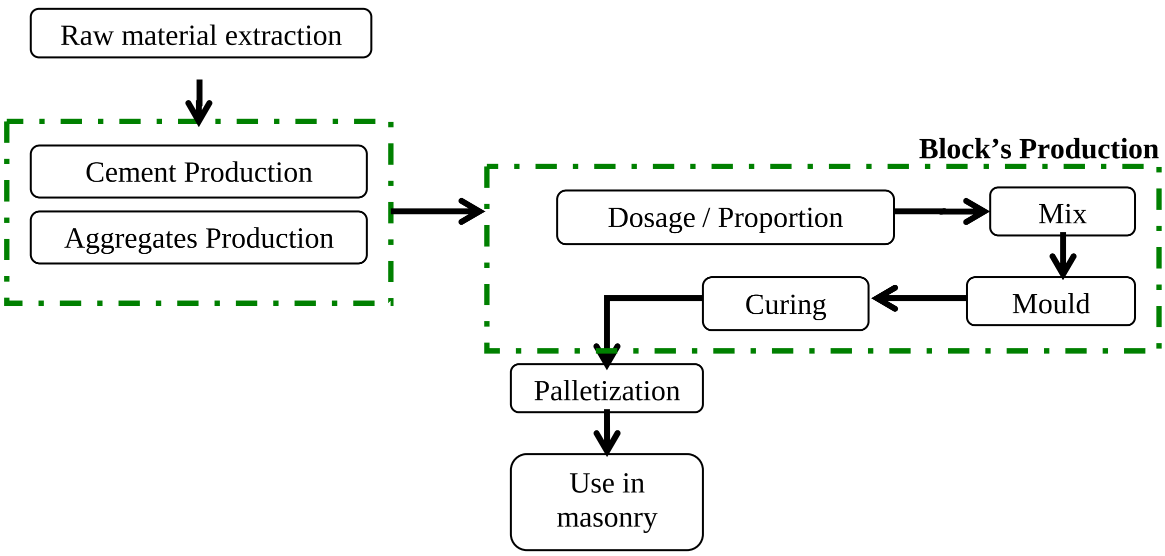
The energy consumption is mainly determined by the firing process. The total energy is $3{,}92 \times 10^6$J or 3,92 MJ / block produced.

3.3 – Concrete block: general aspects of the components production and energetic consumption

The main raw materials used for concrete block are cement and aggregate. The aggregates are sand and stone. The block is obtained by pressing. Figure 2 shows the steps of the concrete block's production.

Four steps can summarize the process. The first one, called dosage/proportion, consists in the fixation of the concrete materials amounts, in order to obtain a specific concrete and blocks with proper characteristics. The second step is the mix; it is a part where the compounds of the concrete will be mixed, usually by the concrete mixer. The third step is the mould, it is the step where the blocks will be molded according to the shapes and sizes established by the production. And the fourth and the last one is the curing, it is a step where the blocks will receive proper humidity and temperature to avoid the water evaporation in the concrete until it gets enough strength.

Figure 2 – Steps of the concrete block's production



In the case of the concrete blocks, we also have variation of the production in Brazil, as the production ceramic blocks.

It means there are factories where the production process is controlled, offering products with high quality, and others where the process isn't controlled.

The factory of the case's study of this paper is located in the Supply's Industrial Sector, in Brasilia. This factory is the most important block's supply of Brasilia. The blocks have a quality stamp and the factory is implanting a quality management system in order to get the process improved and controlled. Table 3 shows the general feature of the factory.

Table 3. Factory's characteristics about the ceramic block production

Dimensions - width, height and length (mm)	90 x 190 x 390
Monthly production (blocks)	200.000
Strength compression (MPa)	2,5
Water absorption %	10
Energy source	Diesel, GLP, electricity and firewood
Raw material origin	Neighbors
Consumption market	Material construction stores of the neighboring area and of Brasilia's

Talking about the energetic consumption, it is a little bit more complicated to count the energetic consumption of the concrete blocks than the ceramic blocks due to the existence of more than one material compounding them.

We have:
- Cement, with consumption of energy according to diesel,
- fuel oil,
- coal and electricity
- aggregates, with electricity and
- diesel.

And at the moment of the block's concrete production, we have:
- Firewood
- diesel
- GLP and
- electricity.

Table 4 shows the energetic consumption of the three steps to the block's concrete production. The total energy consumption is 2,90 x 10^6 J or 2,90 MJ / concrete block produced.

Table 4. Energetic consumption of the block concrete production, including cement and aggregates

Energy	Cement production (J / ton)	Aggregates production (J / ton)	Concrete Block production (J / block)
Diesel	$81,5 \times 10^6$ J	$9,5 \times 10^6$ J	$0,2 \times 10^6$ J
Oil Fuel	$27,4 \times 10^6$ J	-	-
Petroleum's Coke	$1923,1 \times 10^6$ J	-	-
Coal	$1803,4 \times 10^6$ J	-	-
Electricity	$381,2 \times 10^6$ J	$4,2 \times 10^6$ J	$0,1 \times 10^6$ J
GLP	-	-	$1,7 \times 10^6$ J
Firewood	-	-	$0,9 \times 10^6$ J

3.4. Masonry Waste

The solid waste is the material extracted from construction's site and it happens due to many factors, for example, bad material quality, lack of planning and management of the materials in the construction's site, etc.

The waste is visible during the building's construction, but the reasons of the extraction is due to the fact that it can occur prior to construction, as mentioned in these examples.

During the building construction, there are four steps in the process:

- Material receiving,
- stocking,
- intermediate process of manufacturing's products
- final process.

The transportation occurs in all steps. The increase of the waste is related to the process considered in the production of the building, which can be optimized by proper materials, technology and management.

The surveying of waste in terms of quantity is very hard due to the different process situations that we have most of the times (there isn't a standardization process) and also the material's quality.

However, it has improved in Brazil, with some programs such as "Programa Brasileiro da Qualidade e Produtividade no Habitat" and Programa Setorial da Qualidade.

The last program (Programa Setorial da Qualidade) concerns about the material's quality related to the Brazilian guidelines, and it includes ceramic and concrete blocks. Both of those components were just introduced to this program. Besides that, some of the Brazilian guidelines are being revised in order to be improved.

Speaking about masonry and considering ceramic and concrete blocks SPOSTO et al (2000) found the waste numbers in Brasilia's sites as shown on Table 5. Other authors also did this, in Brazil, according this Table.

Table 5. Waste (%) of concrete and ceramic blocks in Brazil and in the area studied

Waste	AGOPYAN, V. et al (1998)	SPOSTO et al (2000)	TCPO (2000)
Blocks and Bricks	17	-	-
Ceramic blocks	-	9,3	10
Concrete blocks	-	3,2	5

The numbers from Table 5 pointed that we have more waste in the masonry using ceramic blocks than concrete blocks.

Generally, concrete block's production is more industrialized that the ceramic block's production. Besides that, we usually have more than one size of concrete block to build the masonry, as ½, ¼ and ¾ of blocks, causing less possibility of waste in the masonry. In the ceramic block case, usually we have just one size of block, so often we need to cut it in order to build some masonry's parts like corners and others.

Speaking about the energetic consumption, considering one square meter (m^2) of masonry, 10 mm of width mortar, and usual components measurement, we calculate the block and energetic consumption. Table 6 shows the values found in ceramic and concrete blocks.

Table 6. Material and Energy consumption / m^2 of masonry built

Masonry	Block Consumption /m^2	Energetic consumption/m^2
Concrete block 90x190x390 mm *	13	37,7 x 10^6 J
Ceramic block 90x190x190 mm *	25	98 x 10^6 J

* Width, height and length (mm)

From Table 6 we can see that ceramic block requires more energetic consumption than concrete block in the cases considered.

CONCLUSION

Between ceramic block and concrete block, we conclude that the first one require more energy in the process in the area researched.

The main step that consumes energy in the ceramic block case is the firing. This consideration goes well with other reference as HENDRIKS (2000).

Besides that negative point, ceramic industry is responsible in Brazil to employ lots of workers, so other studies must be done in order to analyze this importance.

In spite of the concrete block have presented less energetic consumption in the cases researched, we can't fail to remember the impact of its production, mainly in the cement production. This is an important subject for being studied in futures researches.

Speaking about the waste, the results show that the waste is smaller in the concrete block's case in the area studied, but it can't be considered at all times. Brazil is a large country with some places where the manufacturing process of ceramic block is more developed. Some of them offer also many sizes of ceramic blocks and high quality blocks to build the masonry.

The technology development of components production of masonry is different in many places in Brazil. There are several local aspects such as:

- Raw material available
- Energy source available
- Cultural factors
- Workers force
- Etc

All of these factors contribute to this development.

In addition, we observe the environmental aspect, as energetic consumption isn't sufficient to give it a final conclusion. Other aspects as social and economic have been considered in the sustainability studies.

THANKS

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Subcontracting Strategies: The Relationships between Contractors and Sub-Contractors in Brazil

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Abstract
Construction projects in Brazil are more and more undertaken by subcontractors under the direction of a major contractor, according to what is happening in different parts of the world. This paper documents the results of an exploratory study about the level of integration found in a sample of 60 building companies of Florianópolis, a city of some 300,000 inhabitants in the south of Brazil. An analysis was conducted on the contractual relationships between general contractors and subcontractors of 20 companies. The paper initially investigates the issues general contractors have to face when they decide to integrate their business with those of the subcontractors. In order to do so corporate and operational strategies concepts are brought into light. It then investigates the process of organisation and management of subcontractors in these companies focusing on the contractor's and subcontractor's perceptions. An analytical framework describes the contractor and subcontractor relationships including the selection criterion, partnering development, conflict resolution, process control and legal contracts. The data was collected through structured questionnaires. The results confirm the low level of vertical integration in the building industry. The primary characteristic of the subcontracting process is the total submission of the majority subcontractors to the building companies, since the contractual relationships are influenced and dominated by the major party. The subcontractors, general are small companies, which informal process and their origins are in building laborers.

Keywords
Construction firms, partnering, subcontracting, vertical integration

INTRODUCTION

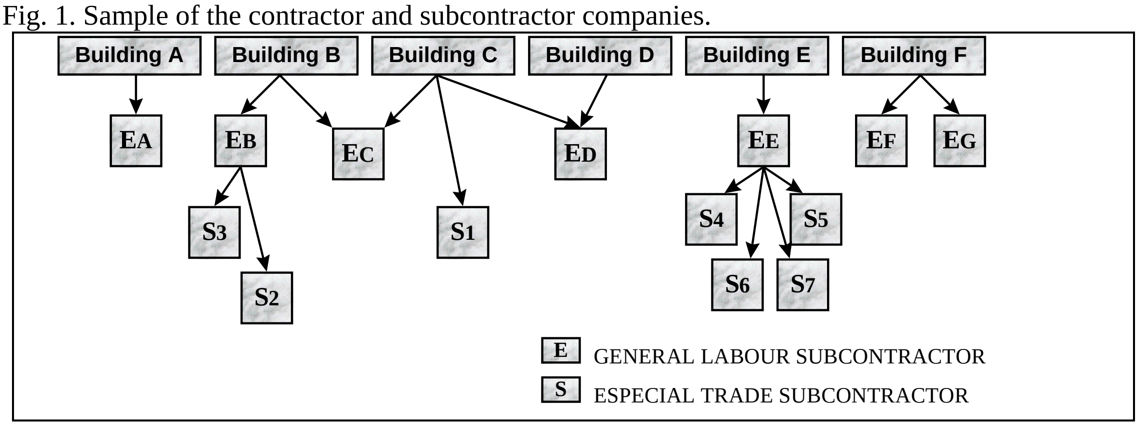
Presently, companies have been searching for new ways of managing and organizing their production in order to increase their competitiveness and productivity (Endoh, 1990). There is a growing tendency for low levels of vertical integration that has been drawing attention to the

outsourcing and subcontracting theories. Within this context, the building industry is referred to as one of the most significant contemporary examples in which outsourcing and subcontracting are the focus of the productive process (Beardsworth, 1988).
This paper aims at identifying and analyzing the levels of integration in a sample of building companies in a city located in the South of Brazil, and at investigating the contractors' and subcontractors' perceptions about aspects such as selection, process control, partnership, problems and conflicts, and legal arrangements.

METHODOLOGY

The experimental research was carried out in two stages. In the first stage, an exploratory study on the integration levels of a sample of 60 building companies was conducted in Florianópolis, a city in the south of Brazil. A structured questionnaire was chosen for this purpose. Such questionnaire was structured around previous literature references on potential activities that might be outsourced and subcontracted by building companies.
In the second stage, 6 building companies from the total of 60 were selected among those that declared their entire productive process to be subcontracted. These contractor companies appointed their subcontractors, performing a total of 14 companies comprising general subcontractors and special trade subcontractors. The sample of the second stage of the research is shown in Figure 1, which illustrates the actors and the relationship between them.
At this stage the data was collected through semi-structured interviews carried out with the companies' engineers and with the owners/founders of the subcontractor companies.

Fig. 1. Sample of the contractor and subcontractor companies.



A GENERAL VIEW OF SUBCONTRACTING IN 60 BUILDING COMPANIES

The level of vertical integration in the companies

The 60 building companies are not specialised in any particular field of the industry, but the construction of residential buildings was predominant, reaching around 90%, followed by the construction of commercial, services and institutional buildings (49%), public buildings (31%) and, in lower proportion, the construction of industrial buildings and others (23%). Percentages do not add to 100% because companies usually reported two or more areas of work.

The amount of construction work performed per year gives an indication of the size of the companies under investigation. The building companies showed a variation between 2,500 and 150,000 square meters built during 1996.

Table 1 shows the impact of subcontracting with regard to the functional areas of design, administrative support, technical advice, building maintenance, industrial relations, transport, equipment hiring, sales/marketing, computing services and legal advice. The figures refer to maintaining these activities within the company itself, outsourcing and/or externalising (the company offers services to third parties).

All the 60 companies studied indicated outsourcing some kind of activity. The companies do not perform all the administrative tasks in-house. Most of them employ directly only industrial relations and computing staff. On the other hand 76% outsource sales and marketing services, 72% outsource legal advice and 52% outsource technical advice. It was observed that 74% of the companies outsource architectural, structural and building services design. In such cases, professionals are hired by the companies for each specific new development.

The fact that 48% of the companies indicated that they outsource hiring equipment suggests that companies look for investing the least possible in fixed assets.

Most companies, about 60% of them, informed that they do not externalise any activity. A lower proportion of them indicate the externalisation of advising activities, equipment hiring and building maintenance. It is believed that such strategy is used by the companies that, having special abilities to perform certain jobs, focus on such activities and start to offer them to external companies.

Table 1. Strategies used by building companies.

Activities	**Ou**	**Ow**	**Ex**	**Ow+Ou +Ex**	**Ow+Ou**	**Ow+Ex**	**None**
Projects	73%	10%	2%	-	10%	4%	1%
Administrative support	4%	77%	-	-	-	-	19%
Technical advice	51%	22%	4%	-	4%	6%	13%
Building maintenance	18%	43%	6%	2%	2%	-	29%
Human resource services	12%	59%	-	-	2%	-	27%
Transportation	30%	47%	2%	-	6%	-	15%
Equipment’ hiring	47%	26%	4%	-	10%	-	13%
Sales/marketing	75%	2%	2%	-	10%	-	11%
Computing services	35%	53%	-	-	4%	-	8%
Legal advice	71%	6%	4%	-	10%	-	8%

Ou - outsourcing **Ow -** owning **Ex** – externalizing

As for the operational labor, about 20% of the companies subcontract all the stages of the construction through general subcontractors and specific subcontractors. Less than 10% does not work with subcontracting at any time, keeping a permanent staff of workers.

The following table 2 show the strategies employed by the companies studied in matters concerning the finish, structure and plumbing and electrical. The figures 2 and 3 show the relationship between the Building companies and their staff.

Table 2. Strategies adopted at the finish, structure and the plumbing and electrical services.

Service	Subcontracting	Owning	Subcontracting + owning	Subcontracting + externalizing	Subcontracting + owning + externalizing
Finish	50%	29%	15%	4%	2%
Structure	53%	31%	12%	2%	2%
Plumbing and Electrical	64%	24%	7%	3%	2%

Fig. 2. Relationship with the steel fixer, the carpenter, the plumber and the electrician.

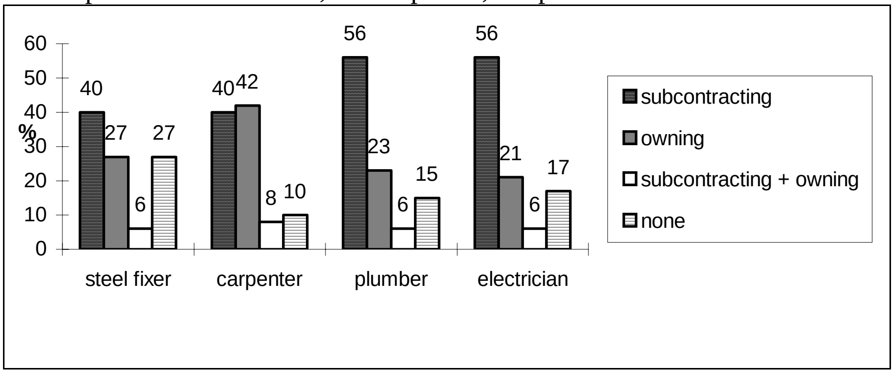
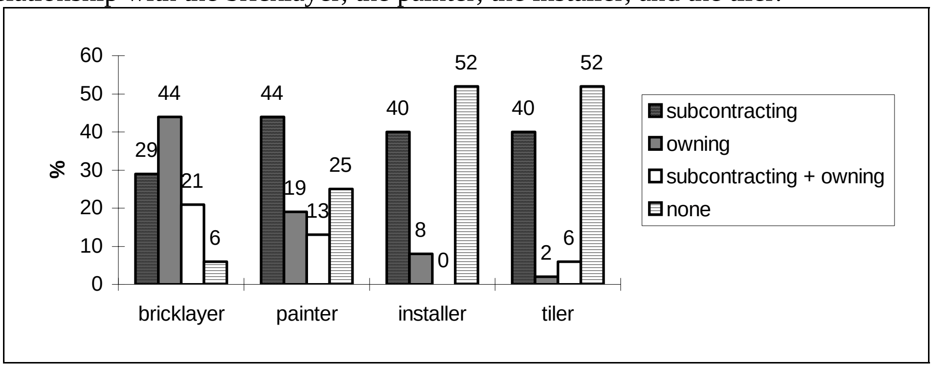


Fig. 3. Relationship with the bricklayer, the painter, the installer, and the tiler.

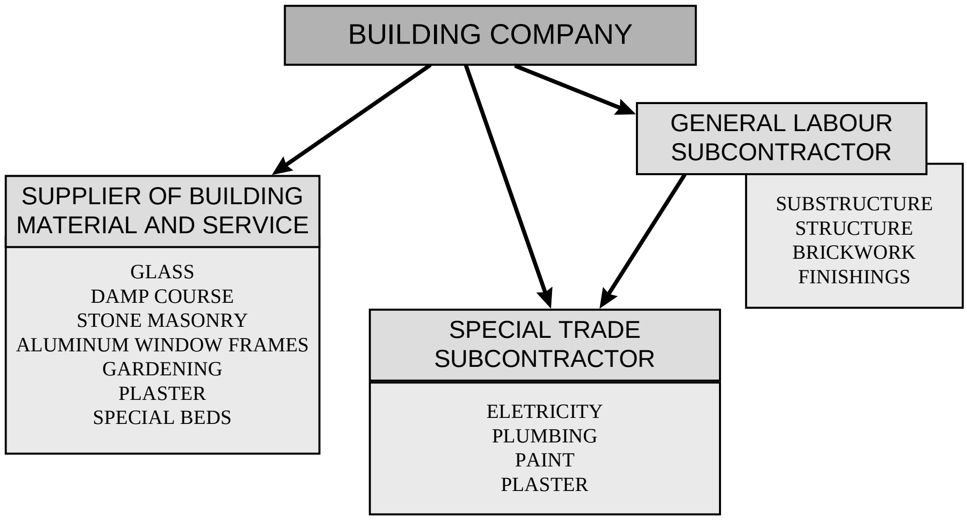


IN DEPTH STUDY OF 20 SUBCONTRACTORS

Organization of the companies with regard to labor

The building companies studied at this stage subcontract their entire productive process as shown in Figure 4. The general subcontractor supplies labour to execute most of the work. Some services that are not executed by him are either arrranged by the subcontractor himself or by the main contractor through special trade subcontractors. The special trade subcontractors are companies that supply labour for certain activities, which in this sample refer to electricity, plumbing, painting and plastering. Note that subcontractors which provide building materials are not considered in this paper.

Fig. 4. Organization of the buildings companies.



General characteristics of the subcontractors

The subcontractors, whether general subcontractors or special trade subcontractors, are small companies with no site planning, no formalization of operational procedures, lack of staff technical qualification and poorly taken administrative decisions. They have their origins in building laborers who establish their own company along with other workmen. After they get some practice in construction work. They recruit labour in an informal way, relying on indications made by their own workforce. On the job knowledge acquisition prevails. There is also an informal way of tendering for new jobs, with prices being fixed based upon the experience of the owner of the subcontractor company. They do not perform detailed cost estimates for each new job.

Reasons pointed out by the companies for subcontracting

The main reasons for subcontracting pointed out by the companies are as follows:
- *Subcontracting as a strategy of the company:* in these cases, subcontracting enables the building company to concentrate its efforts in the feasibility and development stages of the projects from their beginning up to their delivery to the client. The connection between the building company and the construction work is restricted to the supplying of materials as well as recruiting, managing and co-ordinating subcontracted workers.
- *Variability on the real estate demand:* subcontracting is a mechanism for the companies to adapt themselves to the market conditions, tackling the variability and uncertainties of projects. They state the difficulty in keeping a permanent staff with a variable market demand.
- *Costs of the management structure in order to keep a permanent staff*: subcontracting implies smaller fixed costs. This is due to the elimination of both the maintenance of equipment and the costs associated with idle or underused labour on the construction site, as well as the decrease in managerial costs associated with smaller manning.

- *Punctual services:* subcontracting solves the problems concerning the required presence of certain trades only at special points in time throughout the building schedule.
- *Building constructions with specific characteristics:* the singularity of projects requires a unique combination of workers and building materials to be co-ordinated and assembled at the construction site. Subcontracting enables the combination of a much greater variety of building specifications.
- *Industrial relations conflicts between the building company and the workers:* the companies admit that there is a better relationship between the subcontractors and the workers; it is a closer relationship.
- *Legal issues:* subcontracting minimises the expenditures with workers concerning the labour laws and the lawsuits brought by them. In actual fact these lawsuits are faced in the first moment by the subcontractors and only failing them will recall on the major contractor.

The contractor-subcontractor relationship

In order to describe the relationship between contractors and subcontractors, the investigation included the selection process of subcontracting and the supervising of the work. In addition, this study observed whether or not the actors involved developed a relation of partnership. For such purpose, the meaning of partnership for each one of them and the perception about its existence (or not) were investigated. The existing problems between them have also been investigated under the perspective of both contractors and subcontractors. Finally, the existence of legal contracts, their practical application and contents have been analyzed.

Selection criteria

As for the subcontractors' selection, the results confirm an inconsistent and informal process which takes place in a market where price is at the end the main argument. Initially price and quality are the most frequently cited criteria by contractors, but the subcontractors, on the other hand, maintain that the companies undertake their services based on their tender being the lowest price among competitors. The technical profile, recommendation by third parties and previous experience of a subcontractor are attributes that indicate the quality of the services a company is capable of providing and they should be more emphasized. The companies mention that only little attention is being paid to these attributes, with few cases in which the contract was awarded following, for example, a third party indication. It seems that the attitudes of the companies are changing very slowly. They are beginning to highlight the quality of the services provided by subcontractors, their reliance and their experience.

Process control

One of the inherent problems of subcontracting is that the companies face difficulties and even lose control of the process. However, the results of this study pointed out that contractors do not feel loosing control, they maintain that responsibility is transferred, which is a different way of exercising control. The contractor companies justify it by declaring that the development of the work is controlled by the supply of the necessary building materials and that the quality control is carried out by their own technical team responsible for the work. As for labour control, although it is under the subcontractors' entire responsibility, there are contractual clauses that enable the contractor to intervene and to dismiss a worker whenever it is justified. However, the contractor does not have a direct control over the workers in terms of recruiting, allocation and size of the teams. In a way such aspect may be thought of as a positive one since the contractor company does not have to worry about it. The contractors, however, complain about the lack of flexibility in allocating the workers.

Partnering

There is normally a great difficulty for the organisations, and for the subcontractors in particular, to define the expression "partnership". In the subcontractors' understanding the words confidence, mutual aid and dialogue are enough in order to express a partnership relation.

Although it is an everyday expression for them, it is not a homogeneous concept. It is certainly a concept that may be understood without difficulties, but the lack of both a unique definition and a common consent about it may be contributing for a situation in which the daily practice does correspond to the statements made.

Most companies do not keep long-term relationship with their subcontractors, although they admit the importance of them. This fact confirms the existence of strictly commercial connections, where the emphasis given by the companies on subcontractors' prices and the strong competition prevent the formation of mature relationships. This attitude also justifies the fact that the companies do not work with the same subcontractor in all their works.

A partnership also implies the exchanging of abilities and ways of qualifying labour, within a co-operative attitude. However, when asked about the activities taken in order to qualify the subcontractors, the companies did not refer to training and to the development of joint social and cultural events. There are actions only towards exchanging technology but conflicts might arise in this area too. The subcontractors reported that the main contractor might impose them to disclose their way of doing things. The contractors also do not attempt to engage the subcontractors earlier in the projects for planning purposes, and, most of the time there are no common goals.

Problems and conflicts

The study reveals the existence of problems and conflicts between the contractors and the subcontractors companies, which contribute to the lack of a close partnership relation. The problems identified by the contractors show their dissatisfaction with the subcontractors' characteristics, like lack of commitment and incapacity to follow the schedule. The subcontractors, in their turn, indicate problems related to the lack of support from the contractors, excessive changes in the projects, unfair competition and payment problems.

Legal Contracts

All the companies under investigation assured that do enter into legal contracts with their subcontractors. However, it was observed that the existence of contracts was dependent upon both the kind and the amount of work, as well as upon the subcontractor itself. Several times there is only a verbal agreement between the builder and the subcontractor.

The general contractors normally establish contracts with the company, whereas as for the subcontractors, such attitude varies. There is a relationship between the existence of a contract and the reliance between the parties. The building company comes out to be the enforcing agent of the contracts, although it seems that the subcontractors have been more and more interested in entering into formal arrangements due to the market uncertainties. The subcontractors would like to have formal contracts due to its extra reassurance in terms of the financial agreements made by the parties.

The companies estate that the contracts are established only after they have been approved by both parties. Nevertheless, there is dissatisfaction among the subcontractors concerning some conditions imposed by the company which, endowed with bargain power, enforce the contracts to their benefit. When asked about the practical application of the contract both parties affirmed that it generally works fine, except for some changes which get out of control, normally related to the working schedule. The contracts analyzed do not have many differences in terms of their formalities and terms.

CONCLUSIONS

The results confirm the low level of vertical integration in the building industry, in which subcontracting is a strategic choice of the companies, and is especially adopted because it reflects a higher adapting capability of the company to the variations of the market demand, to the unique characteristics of each work, and to the difficulties in facing fixed costs which are inherent to having its own workers (social benefits, equipment and tools). The predominance of subcontracting at the building site is the consequence of several influencing factors that are related to the companies' strategies, the market and the characteristics of the sector.
Subcontracting is established by means of two kinds of subcontractors: the general subcontractors and the special trade subcontractors, whose basic difference is the extent of the service they offer. In both cases, are small companies with no site planning, no formalization of operational procedures, lack of staff technical qualification and poorly taken administrative decisions. They have their origins in building laborers. The organization is the informal way. The primary characteristic of the subcontracting process is the total submission of the majority subcontractors to the building companies, since the contractual relationships are influenced and dominated by the major party.
The results show several points of discontentment between contractors and subcontractors, which do not lead to a relation of partnership. Both parties are still in a stage of resentment due to each other business practices, where expectations are not fulfilled. Despite the great exposure to media exhortations, seminars and conferences, availability of technical and consulting advice, partnering concepts did not make yet their way through the building companies under investigation.

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Future Trends Impact Construction, Real Estate and Facility Management

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Abstract
Not since around the turn of the 19th century, have we seen such dramatic change in the nature of work. We are currently entering the third age of human work, the Knowledge Age. Just as the goals and products of the Agricultural Age changed with the Industrial Revolution, the Knowledge Age requires new goals, products and an entirely new way of working.

The value that built environment professionals add to their employment is rapidly and drastically changing. Those who don't understand and learn more about and embrace these changes will be swept away with the industrial trash. A paradigm shift on a level larger than that of tractors versus mules is required to make this transition. The Knowledge Age requires a knowledgeable built environment professional who has skills beyond the technical, managerial and even the business-savvy worker. Our connectivity and flexibility, as well as our ability to collaborate, will determine our success in the future.

Keywords
Knowledge age, trends, evolution of work.

INTRODUCTION

Organizational changes are already underway in most modern organizations. The computer or PC has dramatically changed the way that we work and how we must design and build offices. Workstations must be wired to accommodate telephone, data and electrical requirements. Even wireless applications require that we, at least, wire the hubs, so that we are truly working in a networked environment. The days of freestanding workstations disappeared in the 1980s as everyone added a computer to their desktop. Efficiency dictates that we hang multiple work surfaces off of a major spine to maximize the power and connectivity routes. Today we have mobile phones, Bluetooth technologies, and we often work from many different areas as we conference, communicate and collaborate on processes and projects. But what impact will future technologies have on our buildings? How will workers accomplish their jobs in 2010, 2015 and 2020?

The construction, real estate and facility management industries typically lag behind other higher tech organizations when it comes to adopting new organizational methods, new technologies and are not usually thought of as "leading edge" companies or organizations. But the opportunity to change that perception and bring a competitive advantage at a global level to your industry, organization and even your country is at hand. But joining this new age and becoming industry leaders takes understanding of the basic concepts of the Knowledge Age and conviction to join or be left behind – that's what this presentation is about.

We need to understand the changes that are occurring in our organizations, society and the world in order to better plan for effective, productive workplaces for our employees, and to provide the construction, real estate and facility management industries with a competitive advantage in today's global economy. This presentation will give you ideas about what some of the future trends are expected to be, where to find information on trends and changes, and how to use this information to adapt yourself, your organization and maybe even your country, to stay abreast of changes and be a competitive player in the future.

THE EVOLUTION OF WORK

Not since around the turn of the 19th century, have we seen such dramatic changes in the nature of work. We are currently entering the third age of human work, the Knowledge Age. Just as the goals and products of the Agricultural Age changed with the Industrial Revolution, the Knowledge Age requires new goals, products and an entirely new way of working.

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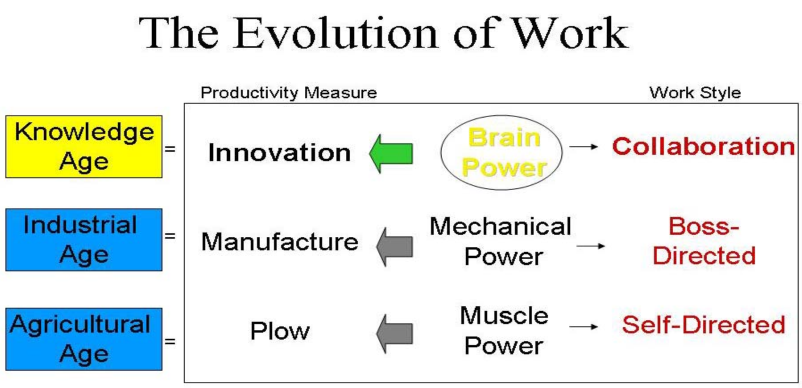
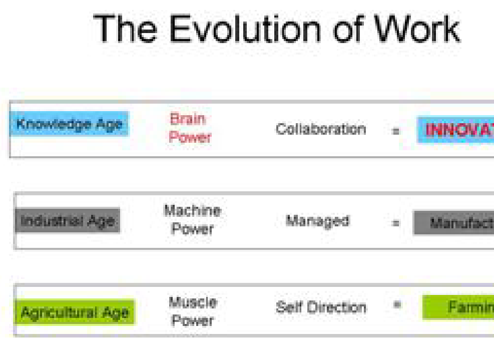
Fig. 1 The Evolution of Work





The Agricultural Age

Throughout recorded history, man has worked the land to provide food to support himself and his family. Men continued to hunt animals, but our primary sustenance came from the planting and cultivation of crops. For centuries this was the primary method of work. The main objective was plowing the land so that the grains and vegetables could be cultivated. His tools were his own, or possibly an ox or mule's muscle. Muscle power was the means of commerce. Farmers were self-directed, deciding whether to plant only enough for his immediate family, or whether to expand and grow enough to support others and possibly set up some trade for other services or items such as meat, since he would now have less time to hunt. This self-directed model meant that each person or each family could move around as they found good land and conditions for growing crops. Tools were carried with them, or on them, as the case warranted. Up until the late 1800s, this was the model for all work. Even those who expanded beyond plowing and growing crops still utilized muscle power and their own self-directed ways of working. Craftsmen exchanged their work to dig clay, mold pots and fire them to make solid vessels for the farmers' crops. Sailors exchanged their toils on the sea for crops and bartered with foreign countries to exchange food and handicrafts bartered from the farmers and craftsmen. This model persisted for centuries until the late 1800s, when machinery began to transform the world.

The Industrial Age

In the late 19th century, machinery transformed the world of work. Inventions, such as the tractor, combine and other farm machinery enabled one man to perform the work that formerly took several men many days to perform. Machinery was faster, and allowed more productivity from each worker. New inventions, such as the automobile and equipment to develop production lines, enabled many workers to come together to produce huge quantities of products. As the 20th century progressed, newer innovations further changed how we worked. Airplanes, refrigerators, radios, sewing machines, and all manner of products were produced all over the world. Man's muscle was no longer the primary tool of work, but mechanical power became the dominant force in work. The primary theme in the Industrial Age was the manufacture of more and more products. Machinery enabled humans to invent new products and also provided the tools to make these in huge quantities for distribution to the masses of people. To handle all this manufacturing, new techniques were required to manage all the humans doing this work. No longer could each human be self-directed, but boss-directed management of this large workforce required new techniques. The new discipline of Management was developed to handle this need. Bosses learned how to best manipulate the manufacturing machines and also learned how to manage the humans who worked with or around the machines. Based on the concept of a machine, theories of work, management and time all have direct correlations to the Industrial Age and its manufacturing theme. Humans were taught to be more efficient, work faster just like the assembly line, avoid irregularities, and conform to the manufacturing model needs. The Industrial Age allowed many innovations for humans, as our way of life and work was expanded during this century-long period.

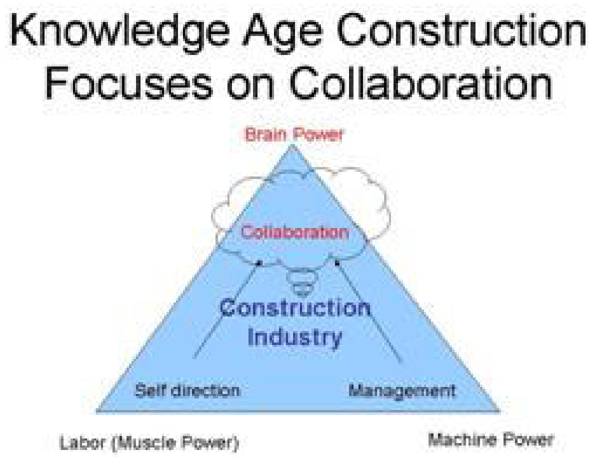
The Knowledge Age

As manufacturing developed and innovations increased, the computer was a part of this development. Advances in the capabilities of computers brought us to the transformation into the Knowledge Age in the last decades of the twentieth century. Since the 1970s, humans have been moving away from the Industrial Age and into the Knowledge Age. But the Industrial Age was relatively short-lived, lasting only about 100 years, and man is still grappling with the transition.

We humans have just started learning the management techniques invented and disseminated in the Industrial Age, and we are slow to abandon them. Our thought patterns and methods of teaching all relate to manufacturing concepts. Consider the "science" that was brought to management theory by Frederick Taylor and Frank Gilbreth in the early 1900s. Their time-in-motion studies were a direct link between the mechanical study of machinery and its application to human workers, for better or worse (Wheatley, 1999, p. 159). These applications are no longer as strong, since workers are primarily concerned with acquiring knowledge and applying information, rather than production in the manufacturing sense.

The Knowledge Age is dawning. Rather than the primary theme of manufacturing, innovation has become the dominant work model. No longer is mechanical power the primary tool, but brainpower is now the tool most required in our employees today. Since knowledge is our tool, boss-directed management is no longer as effective as the new collaborative methods we now use in many organizations. Humans value the ability to think and share ideas in order to gain additional information. Discussion among knowledgeable employees stimulates additional thinking and development of innovations. This is the new model for workers in the Knowledge Age. Collaboration and teamwork are the prevalent models that Built Environment professionals must plan to accommodate today and into the near future. Intangibles are the products that companies value today, which means that organizations must deliver the value to their customers through innovation, ideas and other knowledge efforts (Klufas, 2005).

Fig. 2 Knowledge Age Construction



So, what are the new trends that are associated with this Knowledge Age and its focus on the innovation, ideas, creativity and collaboration among workers?

Drivers of the Knowledge Age

The changes required in the Knowledge Age are driven by many factors but there are seven specific trends which we need to learn about in order to understand and prepare for the future. These seven include technological developments, a strategic focus in business, partnerships and collaborations, sustainability, demographics, globalized responsibilities, and research and education. Each of these have multiple areas of new development and trends are constantly changing, but a focus on these seven will allow the built environment industry to see the need for change and help to provide guidelines for the necessary adaptations that will our organizations to move successfully into a competitive advantage within the near future.

TECHNOLOGICAL DEVELOPMENTS

We have all experienced it – the fear that as soon as we purchase computer equipment, the newer, faster, cheaper model will come out and we're already behind the times. Technology and new techniques based on the technology are changing so quickly that we are all forced to deal with ongoing upgrades and updates. Moore's law is a 1965 prediction that exponential growth in the number of transistors included in each integrated circuit, and which allows miniaturization to increase and costs to decrease for technology hardware. This theory has held through today and is expected to continue for at least another 10 years (Moore, 1965). Moore predicted the growth in microprocessors, which now allow us to carry extremely high rates of computing power with us in miniature forms such as PDAs and microcomputers. This has a tremendous impact in the built environment industry, as we take computing into the field and have all of our staff now working in electronic, rather than manual formats. Our technicians must now understand not only the technical equipment specifications and requirements for operations and maintenance, but also how to electronically interface with equipment and the maintenance management systems supporting our building infrastructure. Construction workers must now have at least minimal computer skills to maintain databases during projects and be able to download updated drawings, specifications and other data needed at each job site.

The building industry itself will be transformed as new materials are invented to make our buildings easier to build, more ergonomically and environmentally sustainable, and more efficient to operate. The transition from construction or maintenance worker to knowledge worker will be vast for many in our industry.

Automation

The wave of automation continues with new devices being developed to help record and report all of the functions of our buildings and infrastructure. For several decades, we have had the automation for drawings and reporting; but the sophistication of these applications now allows us to download information to a single source, where it will be shared among applications, saving the Project Manager or responsible department time in duplicated efforts. Project management software and inventory and asset management software are just a few of the systems we now use. The future of these applications will be a continued ability to access more quickly and from increasing numbers of devices, as well as interoperability of programs, which is listed below in Interoperability of Systems.

Wireless Applications

New wireless applications for multiple uses are rapidly expanding. Our technicians can carry wireless PDAs to remotely input data on equipment or conditions. This instantaneous transmission of data provides real-time updates to our systems and drawings, and allows for faster service delivery to our customers. Enormous time is saved with the reduction of manual updates, and reliability and security of wireless systems is constantly improving. More applications also allow remote control of various building systems. Some of these are even becoming sophisticated enough to self-monitor systems, so that sensors record temperatures and analyze whether or not tenants are occupying the space and then, turn on and off systems and equipment to save energy and allow additional automation to occur. Again, this reduces the man-hours needed to monitor and adjust equipment.

In the near future, expect to see more and more equipment and systems go wireless. In fact, the new standard for equipment and maintenance reporting may become wireless once all the security issues are resolved. No more need to synch our systems, they are remotely and instantly updated as we enter information into our wireless devices.
Wireless technology allows workers to roam and move comfortably about as they accomplish their work. No longer are they tied to a desk or computer, but they can move about and accomplish work as they commute to and from locations. The flexibility to accomplish work anywhere is the promise of wireless applications.

Infrastructure and Furniture

Our furniture and our buildings are developing and providing new and innovative options for Knowledge Age workers. There are chairs with micro-speakers in the headrest to allow individual listening systems that keep sounds contained to only the individual occupying the chair. Other traditional furniture items are being expanded to include computer monitors, display devices and even the computer itself. Building components are also being developed to include display walls and computer screens, for example (Streitz et. al, 1997, p.297-312).

The ability to make our walls, furniture and other components of the workplace function as multiple devices, allows a tremendous savings, both in cost to acquire separate items, but also in the ongoing maintenance of these devices. Rather than purchasing a desk, a computer monitor and a mouse, one piece of multi-purpose furniture that accomplishes the objectives of each is purchased and installed. This also allows for additional savings in the allocation of space for employees. If a conference table can house computer displays, then perhaps we no longer need to provide individual workstations for specific employees. A work surface interface is all that is needed for a worker to being computing, rather than a large workstation with dedicated computer, monitor and mouse. Now many employees carry a laptop computer, but even this need will be reduced when our furniture incorporates our computing devices.

New materials are even being developed that will change the way “walls” are perceived. Materials that allow air and/or light to pass through them may soon change the way that we build and utilize buildings. These “nanofibers” will also posses phenomenal thermal and strength properties (Bacon, 2004). Our view of “hard-walled construction” will change as materials are invented and adapted to provide more flexible options for the users. Other new technologies allow walls to be built to withstand blast forces, providing additional security in this new age of terrorists threats. New technologies will provide opportunities for new materials and new uses of existing materials, which will require training for construction workers to adapt and modify current practices.

The way that we design and construct buildings is also being heavily impacted by new technology. Software that provides 360-degree animation and walk-thru capabilities give designers and engineers a new “view” on the design of buildings. Researchers are even testing robotics that can build complete buildings after being programmed with the total design. This could totally reposition the role that many current construction workers play in the build out and move them from “blue collar” laborers to Knowledge Age maintenance and supervision of the robotics that construct the structure. This will not replace current methods, but will be a competitive advantage for those in the industry who can adapt and adopt the new, more advanced technologies.

Interoperability of Systems

As our automated systems expand, the need to have them “talk” to each other is growing. Rather than several databases with separate data, the goal is to integrate these systems and have only one entry of information, which populates multiple applications simultaneously. Interoperability is a hot topic for providers of technology applications. Expect to see improvements in interoperability, as well as global standards in the near future. The real estate industry already has Open Standards Consortium for Real Estate (OSCRE), which is standardizing many technological areas of commercial real estate. As new methods are developed and presented to the market, additional groups will be needed to standardize the technology in each specific field.

STRATEGIC FOCUS

Since the 1970s, business processes have become more strategic. With the realization of senior management that buildings are long-range assets for an organization, the focus for facility management has become more important and more strategic. The attention of senior management, while welcome and needed in our industry, also forces us to look at our definitions and body of knowledge, to ensure that we are in alignment with the overall organization’s mission and goals. The real estate property management and construction industries see a similar need to become strategic in the planning and development of new projects.

While Facility Management is responsible for the performance functions and optimization of the running cost of our building(s), we must also ensure that the asset is efficiently and suitably run to deliver the expected people, process and technology requirements of the organization. As the strategic focus is given more importance, Facility Managers will need to continuously develop more complex and longer-term plans to meet the strategic needs of the organization. As the organization develops, more and longer-term plans, facilities, real estate and construction must all be a part of that development.

Within developing countries, the opportunity to leapfrog with new infrastructure development is a real opportunity. For example, in the telecommunications arena, the developed industrial nations already have a huge investment in the assets of traditional telecommunications backbone infrastructure to support land line architecture. New cellular and wireless technologies require additional capital investment to duplicate service and provide an overbuilt status for the industry. This results in depressed stock market values and reduced revenues. However, many developing countries are skipping ahead and avoiding this huge duplication in infrastructure investment by moving directly into wireless communication technologies and supporting infrastructures. This avoids duplication of investments and provides the developing country with more lean, agile and flexible infrastructures without the duplicate investments, a huge competitive advantage when ongoing maintenance and upkeep are calculated into the equation.

PARTNERSHIPS AND COLLABORATIONS

The construction industry, as well as real estate and facility management, function as support to the core business of most organizations and, therefore, have long been partners with other support departments within the organization. New alliances and partnership models are increasing with outsourcing, as a result of cost containment, which is so common in large organizations today. In some organizations, the Facility Management department has become primarily a contract management organization, managing multiple vendors and partners. The implementation or tactical role is contracted to vendors or service providers who specialize in each area of competency.

Therefore, negotiation, financial and interpersonal skills are highly valued in the facility management field of the future

Information Technology

Today's Knowledge Age workers interact with the Information Technology departments or groups for connectivity to enterprise systems and remote access authentications. If Information Technology is not an upfront partner in each project, success will be difficult or impossible, since each new occupancy, relocation or major change requires that phone, data and other technologies be coordinated for installation. Many projects have failed after long, complex and successful construction completion, due to a lack of coordination with Information Technology specialists. And what employee can be productive without connectivity to data and Internet or intranet systems? We are as dependent on IT for productivity as workers in the Knowledge Age were on electricity.

The innovation and change mentioned earlier are another component of our relationship with Information Technology departments or specialists. The constant rate-of-change dictates that we will not be experts in this field, but we must stay abreast of the major changes to anticipate the infrastructure changes or upgrades needed to keep pace. The Information Technology departments can provide guidance and advise as we integrate our systems with enterprise systems. This will only continue as we move more workers into Knowledge work.

Human Resources

Human Resources are an organization's largest assets. Human Resource departments are charged with effectively managing this huge cost. Therefore, our relationship with HR can be beneficial to managing our facilities, planning projects and executing construction – if we leverage the information that can be learned by working with HR, especially during planning cycles within our organization.

Understanding the key motivators for employees is another step in helping to identify ways to provide the best workplace solutions for our organization. Human Resources should be a good source of information about these workers. As salary is often no longer the primary motivator for Knowledge Age workers, we need to understand how workplace settings impact our employees. While we anxiously analyze costs to reduce overhead and cut excess requirements, the total cost of our organizations employees is 13 times more costly than the operations of the facilities to support them (Building Owners and Managers Association, 1996). A small increase in employee productivity can impact our organization's bottom line much faster than energy savings or other building cost savings. This does not remove our responsibility for reducing costs wherever possible, but should focus our efforts on providing an effective and productive workplace for the Knowledge Age workers we support.

Outsourced Partners

Not a new trend, but a growing trend, strategic partners, allied providers and expanded outsourcing is continuing as organizations focus on their core competencies and contract with specialists to provide many of the non-core functions. As the Knowledge Age continues, this is a natural progression as organizations focus on the knowledge needed in their specific industry and leave the multiple tasks outside their core to others. For the construction and real estate industries, the need to partner with others is growing as Design-Build, Public-Private Partnerships and other new

strategies become more prevalent. The skills to negotiate with other organizations to provide mutual benefit to our customers are a new skill for many within the industry.
Many organizations tell us that they will continue to outsource until only strategic decision-making and major management remain. These organizations often expand current outsourcing vendor responsibilities to convert them to Alliance Partners or Preferred Partners. This trend is continuing and expected to grow in the future.

SUSTAINABILITY

The Green movement is now worldwide and many countries are adopting stricter regulations for new and renovated buildings. This benefits all mankind, but directly impacts how we plan, design, build and operate buildings. No longer can we look selfishly at what our needs may be today, but this Green movement requires that we adopt new, more sustainable measures in the construction and operation of buildings. Expect to see new regulations requiring minimum levels of sustainability in future construction projects in many parts of the world.

Many sustainability measures are in place globally to help Facility Managers and builders use more green methods in their practice. However, there has been some resistance in many organizations, primarily due to costs. The need to experience a paradigm shift in environments, so that the focus is moved from an operating cost perspective to a total cost of ownership or life-cycle cost perspective, is required. As this focus changes, a key to maximize the return on investment for facilities will be the use of total cost of ownership analyses that demonstrate sustainable first costs are vastly outweighed by life-cycle cost or total cost of ownership. Currently, the U.S. Green Building Council estimates that a LEED certified new building costs approximately two to ten percent more in first costs than a non-certified building. Over the 20-year life of the building, these costs can be returned in a short time frame and provide ongoing efficiencies and savings to the organization (U.S. Green Building Council, 2004).

As more and more users of sustainable or “green” products buy and use products, the developers can reduce costs. Already, we have seen costs begin to decline for specialized “green” products as more and more purchases are made. New products are also being developed for the “green” market. Whole new industries are developing to meet the needs of sustainable developers and operators of buildings. The carpet industry has been quick to respond to customers desire to avoid waste and has developed “remanufacturing” methods to take used carpet, remove the backing and use both backing and the old carpet fibers. Carpet fibers are reprocessed to become new fibers for new carpet and the backing is melted or chemically reprocessed into new backing. These processes are often more energy efficient and reduce both waste going into landfills and reduce the raw materials needed to manufacture the carpet product. Other similar products in the construction and furniture industries are also being designed for recycling and re-use. As customer demand increases, more products will become available worldwide. The aggressive, highly competitive companies will be offering these sustainable options to their customers and can generate global recognition for their sustainable efforts.

DEMOGRAPHICS

Global demographics are dictating a huge impact as population changes dramatically in the workforce. In Canada, Europe and Japan, the baby boom generation has already completed most of its productive work years and workers are retiring and leaving the workforce faster than new generations can replace them. Today, between 10 and 19 percent of the workforce are over 60 years old in these countries. In 2050, it is expected that almost 30 percent of the population will be over 60, leaving too few trained workers to replace current employment (United Nations, 2002).

This trend means that innovation and technological advances must continue if nations are to find a solution to the employment problem. In the short-term future, within the next five to 15 years, we can expect that, globally, the need to retain and attract the best employees will be a high priority for organizations as they compete for good talent. The Real Estate and Facility Management groups are a key driver in providing the inspiring, motivating workplace that accomplishes this mission, with the construction industry providing the build out. This means that attention to the customer needs will need to be a primary focus in designing and operating buildings in the near future. This does not appear to be as severe a problem in Latin America in the coming years, but global developers and builders will need to understand this trend if they intend to compete globally for work and workers.

The multiple generations now in the workforce also impact how we design and operate workplaces. Very different environments are perceived as productive for different generations. For example, most Boomers have come to expect a quiet, calm work environment. The expectation of offices with hard walls and doors is a reward system expectation for those who have worked long and hard to “get where they are.” However, the GenXers are much happier with a rich sensory environment (read: music playing, television on, computer e-mail and instant messaging all occurring simultaneously). GenXers often prefer not to be enclosed and want the open exchange provided in collaborative settings. Their reward expectation is not a corner office, but the latest, cool equipment and amenities at the workplace. Managing these multiple expectations can be expected to be the norm in the future.

GLOBALIZED RESPONSIBILITIES

Many organizations currently operate in the global arena and more are expanding their operations to include global locations and workforces. Years ago, more maybe currently we only operate within one city. But today, a portfolio of multiple buildings in countries throughout the world is not uncommon for organizations. Learning the social, cultural and financial differences is a huge task when operating globally.

World partners and alliances will become key to managing people, places and processes over the entire globe. The ability to understand varying financial concerns, legal requirements, multiple technologies and the collaborative process will be required for global success in the built environment industry. Networks of providers are springing up to meet this international challenge. Technologies are available today to provide collaborative work tools to meet the needs of global projects and we need to take advantage of these if we are to become global competitors in the Knowledge Age.

RESEARCH AND EDUCATIONAL NEEDS

I would be remiss without addressing the educational and research needs of the built environment community. The need for the development of a solid theoretical foundation and training of skilled Knowledge Age workers is needed for success in these trends presented today. The body of knowledge is growing, but with the pressures of time and the demands of the job, too often we ignore the requirement for regularly published descriptions of good practices or a strong body of ethics that can be used to regulate the industry globally. In the words of an old Chinese proverb, "If you are planning for a year, sow rice; if you are planning for a decade, plant trees; if you are planning for a lifetime, educate people."

Collaboration with our industry partners is needed to provide the academic research and teaching that will result in built environment executives who have similar responsibilities to today, but who have greater authority to act and integrate the entire business planning process for their organizations in the future.

Just within the Facility Management industry, the European Union's Standardization committees and other work groups on Facilities Management are a step in this direction for Europe. The International Facility Management Association now has two designations for facility professionals. The Certified Facility Manager designation is an experience-based exam with qualifiers for education and experience in the field. The new Facility Management Professional designation is intended for new practioners in the field and offers course-based curriculum for these new in the industry. The Facility Management Association of Australia has a Facility Management Accreditation System (FMAS) in Australia and the British Institute of Facilities Management BIFM Qualification in the U.K. are a start, but more is needed to unite this profession as it expands globally. Similar organizations, such as the CIB, can provide this global view for the built environment industry.

CONCLUSION

As we move forward in the Knowledge Age, our ways of working and the buildings we provide to support workers is changing dramatically. Just as the Industrial Age provided automobiles and retired horses, our technology is providing new and creative ways for us to work more collaboratively with our brain power, rather than just muscle or machine power. Open-mindedness to new ways of working will be required for success in the future. We need to decide now to develop new skills, a learning atmosphere and open-mindedness, or we will be left behind as the Knowledge Age progresses.

The opportunities for developing countries is even more dramatic, since the ability to leapfrog other industrialized nations provides a unique competitive advantage in today's global economy for those willing to learn the new technologies and adapt Knowledge Age concepts to their organizations. I encourage you to consider these trends and continue to learn more about the changes the Knowledge Age brings. Rather than relying on industrial, mechanized management theories, the newest trends will provide a fresh collaborative style to adopt for maximum advantage into the future.

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Identifying the Factors that Influence the Use of Construction Partnering as a Procurement Strategy

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Abstract
The use of construction partnering as a procurement strategy has been inconsistent across construction industries globally. An incongruity exists between the strong advocacy of the use of partnering in the construction literature on the one hand, and the lack of actual adoption in reality by construction firms on the other. This paper argues that a main reason why there is this gap between research and practice is that there has been insufficient systematic studies by academics of the critical factors that underpin the selection of construction partnering which construction firms continually take into consideration. This paper reports the results of an empirical study which looks at how much these factors influence construction partnering under different industry characteristics. The results demonstrate that construction firms are far more discriminating in their choice of procurement strategy than what the literature would appear to suggest, and therefore, construction partnering should not be viewed as a one-size-fits-all means of improving project performance. This paper highlights the use of construction partnering is likely is contingent upon a set of industry factors that affect firms. Suggestions for future research to expand on the current study are offered.

Keywords
Construction partnering; procurement strategy; procurement selection; project performance; institutional factors

INTRODUCTION

Construction partnering is still popularly regarded as "the most significant development to date as a means of improving project performance" (Wood and Ellis, 2005, p.317). The steady stream of literature highlighting the potential benefits of construction partnering is widely accepted as an endorsement of its use as a choice procurement method in the construction industry (Bennett and Jayes, 1995; Black et al, 2001; Egan, 1998; Chan et al, 2003; Cheung et al, 2004). However, despite the continued popularity of construction partnering, no apparent industry trend exists to show that it is now the dominant choice of procurement method. The once valid argument that the absence of the widespread use of partnering is due to negative perception and attitudes among practitioners could no longer be substantiated because recent studies have found that attitudes towards partnering are becoming more and more positive (Wood and Ellis, 2005). Thus, other pertinent reasons exist which account for the discrepancy between the supposed tangible benefits that partnering brings and the lack of its adoption in reality.

This paper argues that one of the reasons for the patchiness of the adoption of partnering in the industry stems from the fact that construction firms do not appear to all jump on the partnering bandwagon despite its potential benefits. The commonly used term 'potential benefits' found in the literature would seem to suggest that in order to achieve the associated benefits, partnering must be contingent upon certain factors that make it an obvious choice of procurement method for construction firms in the first place. Therefore, the appropriate question here is not whether partnering is a more superior procurement method. Assuming that it is, given the positive endorsement that it receives, the question is why the majority of construction firms are still not using partnering to replace other traditional procurement methods? Following from this, the next question is what are the determinants predicting the likelihood that construction firms will adopt partnering? There are compelling reasons for asking these questions because if what is being preached by academics is not being practiced by the industry there is a need to understand (i) why does the gap exist and (ii) how can it possibly be bridged so that the rigour and applicability of the research and practice nexus can be strengthened further.

This paper reports the preliminary research findings that shed some light on the above questions and suggest ways in which this line of inquiry could be further developed to validate the results so far obtained.

Using institutional frameworks to explain partnering arrangement

Construction partnering as defined by Construction Industry Institute (1991) consists of "…a long-term commitment between two or more organizations for the purpose of achieving specific business objectives by maximising the effectiveness of each participants' resources". In this regard, it is no different to any other types of inter-organizational alliances which "operate in a relational context of environmental interconnectedness" such that "an organization's survival and performance often depend critically upon the linkages to other organizations…." (Oliver, 1990 p.241). To this end, several theoretical perspectives exist to explain and predict the establishment, development, process, and outcomes of various forms of inter-organizational relationships. While transaction cost and resource dependency theories have been used in the past to explain construction organizational phenomena, one germane theory which has so far been neglected in the construction management literature is the institutional theory (DiMaggio and Powell, 1983).

A rich body of organizational and strategy literature exists to explain how and why institutional forces are important factors that contribute to the creation of different inter-organizational structures and alliances (e.g. Scott, 1987, 1998; Scott and Meyer, 1994; Zucker 1987). Institutional forces that arise from specific regulatory institutions (e.g. laws, regulations) and, normative and social norms (e.g. professional conformity, industry and societal expectations) will to a certain degree influence business decisions and organizational actions. In other words, the contexts in which business decisions are made are affected by pressures of firms seeking social conformity, and compliance with rules, regulations and norms which, in turn dictate what are regarded as desirable or legitimate business endeavours. The compliance with norms and regulations is deemed important because firms that conform "are rewarded….through increased legitimacy, resources, and survival capabilities" (Scott, 1987 p.498).

In addition, institutional theory suggests that because firms seek legitimacy, new organizational arrangements emerge as a result of firms attempting to achieve a fit with their institutional environments such that "firms within the same population facing the same set of environmental constraints will tend to be isomorphic to one another and to their environment…" (Dacin, 1997 p.48). Thus, when the same institutional pressures continue to exist over time, firms will become more homogeneous in what they do (DiMaggio and Powell, 1983) and as a result, a dominant organizational arrangement or 'proto-institution' (Lawrence et al, 2002) is likely to occur. Extending this argument to the construction industry, it can be argued that partnering arrangement has yet to achieve the status of 'proto-institution' where its practices, rules and technologies become so entrenched such that firms are compelled not to choose other practices, rules and technologies which are likely to make them less competitive.

METHODOLOGY

Using trade association and chamber of commerce directories, a questionnaire survey was administered to a population sample of 2602 foreign and local firms in Hong Kong which was framed from different sectors of the construction industry. The sample was believed to represent all construction firms operating in Hong Kong for which contact details, including the name of the most senior executive, were available. After two mailings, a total of 526 responses were obtained. A total of 270 firms were related to the construction contracting industry; 110 were construction consulting firms of one type or another, a further 101 firms belonged to the construction manufacturer and supplier industry; 15 firms were construction developers. Three hypotheses were developed to firstly test the relative importance of institutional factors and economic (financial) factors in predicting the use of partnering by construction firms, and secondly to test to what extent the use of partnering is influenced by firm perception of strong partnering norms within the industry. The variables used in the study were those that measure the (i) level of partnering use, (ii) perception of norms and expectations for partnering, (iii) firm competitiveness and profitability due to partnering use. Control variables such as size and age of firms were included to control for possibly confounding firm demographic effects, which may have an impact on firm's likelihood to use.

DISCUSSION OF RESULTS

This paper forms part of a larger research project that is currently underway to study partnering practice and the detailed empirical study based on the 526 data sets to examine the role that institutional factors play in the creation of partnering arrangement is reported elsewhere. This paper highlights some of the key findings obtained so far and discusses the implications they have for future research in partnering practice.

In support of the research hypotheses, the findings have clearly shown that partnering use is much more heavily influenced by industry norms and expectations for partnering than by the sole financial benefits that are associated with its use.

This is in stark contrast to the widely held view that firms are able to benefit financially from using partnering and, hence the assumption that such benefits alone would necessarily predict the use of partnering, the findings have shown that none of the financial incentives in terms of increased profitability, increased competitiveness or increasing the likelihood of firms winning contracts and securing business deals has any significant impact on partnering use at all.

However, the findings suggest that firms with a perception that partnering norms and expectations exist strongly in the industry are motivated to adopt partnering as conforming to such institutional pressures would add greater legitimacy and credibility to what they do. By complying with institutionally salient norms, firms view their choice of using partnering as rational because the added legitimacy might result in improved firm profitability through increased resource acquisition and reallocation. Therefore, the extent to which partnering is deemed profitable seems to be dependent upon how institutionally entrenched the practice of partnering is in the construction industry generally - the more embedded the practice is, the more likely firms will be inclined to its use.

Hence, the question of why there has been no visible pattern of firms using partnering across the construction industry can perhaps be pinned to the lack of systemic, overriding institutional pressures that drive its use. Without such pressures, it can be argued that firms view partnering as just one of the range of procurement methods that are available to firms and the decision to use partnering or any other methods will then rest more squarely on economic and market factors. Because the benefits, or more precisely, the economic and management advantages that firms could gain from using partnering is still debatable and difficult to measure, there is no *a priori* reason to expect firms to favour its use over other procurement methods other than the fact that there is obvious institutional norms that propel firms to use it.

IMPLICATIONS FOR RESEARCH AND PRACTICE

Despite the strong advocacy of partnering use and of the purported benefits that it brings, it seems ironic that its implementation has remained at best, at a modest rate across construction industries. Past studies suggesting that the construction industry operates on a very competitively cost driven environment have helped to partially explain the reason for the lack of incentive for firms to use partnering (Bresnan and Marshall, 2000; Wood and Ellis, 2005). However, examining the issue from a totally different perspective, the results of this study show that institutional norms for partnering is an important contributing factor determining when firms are likely to use partnering. This has significant implications on the way research on partnering should be undertaken in the future. Rather than focusing on the purely economic determinants, studies should consider using institutional factors to explain and predict partnering formation. As far as this study is concerned, institutional forces far outweigh the importance of economic forces in determining partnering occurrence. Firms are inclined to use partnering not so much because they see it as a superior procurement method that brings increased firm profitability or competitiveness *per se* but rather because they see that there is an advantage in the face of strong industry norms and pressures to use it. Hence, future studies could usefully focus on how specific institutional pressures (i.e. regulations, policies, rules) determine the occurrence of partnering and to what extent. It appears from this study that the lack of strong institutional partnering norms in the industry largely explains why the implementation of partnering has remained patchy. One possible research avenue that stems from this would be to explore differences in the level of institutional pressures that construction industries in different countries have in relation to partnering practice and determine how this may in turn affect the level of partnering use. Perhaps this will then inform practitioners about where to divert their resources that will bring about the most sustained economic performance. These new lines of inquiries will shed much needed light on what actually determines partnering occurrence and why – a timely endeavour given the history of partnering research has been predominantly focused on economic factors.

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Introduction of Sustainable Low - Cost Urban Housing with regard to Techno-Economic Aspects and Prevailing Attitudes - A Case Study.

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Abstract
The great majority, by estimation about 80 %, of the urban dwelling houses in the Kambaata region in Ethiopia are built according to a traditional technology. This means walls consisting of a framework of wood covered with clay and roofing consisting of corrugated iron-sheets. In general the standard is low and the need of improvement is great.

It is appropriate to try to introduce new house building technology based on adobe blocks and/or cement stabilised soil blocks. Executed projects have shown that it is possible to erect durable buildings with these types of blocks. The introduction must be done with regard to the dwellers financial ability and with regard to prevailing attitudes in the society.

By estimation the cost of erection of about 80% of the dwelling houses in Durame, the main town in the region, was less than 30.000 ETB (1 ETB = approx 0.115 USD at present). This figure indicates the very low cost levels that must be obtained if an introduction of a new technology shall have the desired impact and that adobe blocks must be used in most cases. However building houses from mud and working with clay has low status in Ethiopia. In other words social stigma is attached to working with clay or mud.
To develop a new building technology alone is not enough. An introduction of a new technology must also take into account societies' attitudes. That can be done by an active participation of the community and a systematic awareness building based on demonstration projects.

Keywords
Sustainability, low-cost housing, attitudes, new building technology, awareness -building

BACKGROUND

General

As most of the developing countries, Ethiopia has a high population growth-rate, at present about 2.7%.This in combination with a high population density contributes in many regions to a rapid pace of de-forestation. The consequences are well-known: soil-erosion, environmental degradation, shortage of fire-wood and scarcity of timber for construction. The Kambaata Region in South Central Ethiopia has a very high population density; 300 persons/sq. km [Bielie et al (2001)]. This puts a very high stress on the natural resources in the region. Even if the de-forestation and erosion problems have not yet had a severe impact on the region, it is reasonable to anticipate that these problems will be accentuated in this region in coming years.

Juniperus Procera Hochst and *Hagenia Abyssinica* are two indigenous species in Ethiopia well-known for their durability in connection with construction. However, these two species have been almost eradicated due to de-forestation. Lack of durable timber for construction has made the construction of durable houses expensive and unaffordable for ordinary people who are forced to almost entirely depend on fast-growing Eucalyptus which is less resistant to termite-attack and which has much lower durability. The effect of this is obvious: shorter lifetime for the houses, further deforestation and, generally, a lower level of standard of living.
Several attempts have been made and are being made in Ethiopia to introduce new, sustainable low-cost housing technologies. However, up to now no major systematic study or test has been made for the Kambaata Region.

Urbanisation

Uncontrolled urbanisation is another, highly visible, problem of contemporary Ethiopia. According to Tarekegn Aseffa (2002) today about 15 percent of the Ethiopian citizens reside in urban areas, principally in the capital city Addis Ababa. Ethiopia is one of the least urbanized countries of Sub-Saharan Africa. At the same time the country is one of the fastest urbanizing ones. Unfortunately, rapid urban growth is occurring in Ethiopia, which is a country with very small resources to meet the basic needs of the population in urban areas, [Tarekegn Aseffa (2002)]. The flow of people from the countryside to the cities is of course most accentuated in Addis Abeba. However, urbanisation is a reality also in minor towns. An uncontrolled flow of people from the countryside into the towns will very often result in deficient housing conditions.

Initiated Project

Against this background a research project named "*Sustainable Low-Cost Housing – needs, possibilities and attitudes. A project with focus on the Kambaata Region in Ethiopia*" has been initiated at Halmstad University. The aim of the research project is mainly to develop and test new, sustainable, low-cost, house building technologies intended for ordinary people. This shall be done with regard to local traditions, needs and affordability.

Executed Pre-Study

This paper is based on the results from a pre-study executed in 2003, [Hjort and Sendabo (2003)]. The general aim of this pre-study was to collect information on which the planning of the major project could be based. A major part of the pre-study was a field-study in Ethiopia with focus on Kambaata. The following four methods have been used:

1. Literature survey.
2. Structured and spontaneous interviews. These were held mainly in Southern Ethiopia. With some exceptions these interviews were held in the native language of the interviewed person. All interviews were recorded.

3. Observations in connection with study-visits to completed and ongoing low-cost housing projects.
4. A minor specific study including ocular observations and interviews was made as regards dwelling houses in the town of Durame, the administrative centre of Kambaata. This town has about 20.000 inhabitants.

AIM AND APPROACH

The aim of this paper is to present and discuss conditions and possibilities as regards introduction of new sustainable low-cost housing technology in an urban context in the Kambaata Region. This discussion is based on information obtained in the pre-study described above.

LOW-COST HOUSING FOR URBAN CONTEXT IN KAMBAATA

General

In this chapter the introduction of a new, low-cost, house building technology intended for urban context in the Kambaata Region is analysed. The analysis is structured according to the following:

- Technical aspects
- Affordability – cost limits
- Attitudes towards a new building technology

Technical aspects

The traditional way of building urban houses in the Kambaata Region can shortly be described as follows:

Foundation (if any): of stone
Walls; outer as well as inner: Framework of timber, mainly eucalyptus, covered by mud
Roofing: Corrugated iron-sheets resting on trusses and purlins of eucalyptus
Doors and windows: locally fabricated from timber
Flooring: Stamped earth floor. In rare cases cement/concrete flooring
Ceiling: Usually nonexistent. In rare cases there is a ceiling consisting of cloth.

The traditional urban dwelling house is usually of quadratic or rectangular shape.

The picture given above is of course very rough. In reality there are variations of different kinds. Some of these variations are shown in results obtained from the study executed in the town of Durame.

This study comprised two parts. Firstly a survey, based on ocular inspection was carried out. This survey comprised 400 houses which is about 18% of the total amount of houses in Durame built before 2001. These houses were randomly selected. The result from this part of the study is presented in Table 1 below.

Table 1. Dwelling houses – main building material for outer walls

Type of material	Frequency	Percentage
Wood & mud	327	82
Concrete blocks	38	10
Bricks	13	3
Other	22	5
Total	400	100

In a second part of the study 50 house owners, randomly selected from the 400 houses mentioned above, were interviewed and their houses were investigated more carefully as regards present condition. The result is presented in Table 2.

Table 2. Condition of the dwelling houses – observed defects on 50 sample houses

Observed defect	Frequency	Percentage
Construction not completed	3	6
No special foundation	10	20
Attack of termites	10	20
Mud on wall damaged by rain-wash	10	20
Roof leakage	4	8
Exterior walls not plastered	4	8
No visible defect observed	9	18
Total	50	100

Table 1 clearly shows that the traditional way of building houses is very dominant. Table 2 shows that many of the houses in Durame have defects; some of them serious. These two tables indicate that the need of improvement by the introduction of a new, sustainable house building technology, is great.

The aim must be to introduce a technology that provides the dwellers with durable houses combined with a healthy and convenient indoor climate. The introduction of a new, sustainable building technology must of course have the traditional way of erecting houses as a starting-point. A very important initial part will be to gradually replace the traditional way of building the walls with a new technology that is more durable, e.g. as regards attack from termites, and that is more sustainable with regard to the amount of timber required. Two possibilities for this are obvious: use of Adobe Blocks (AB) and the use of Cement Stabilized Soil Blocks (CSSB).

The use of Adobe technology is not yet common in Ethiopia as a whole, although there are examples of buildings that were erected many years ago and that are still functioning well. In the middle of 1950s, Swedish Mission BV constructed an elementary school building with Adobe blocks in Alemaya about 500 km east of Addis Ababa. According to [Nilsson (1954)] the building was the first of its kind in Alemaya to be built entirely with mud blocks.

The walls, which were founded on a stone-masonry wall, were plastered, presumably with lime-cement mortar. This building was used as an elementary school up to 1990, when it was converted into a dwelling house. Although this building was repaired and maintained during the years, it clearly shows that such buildings built from adobe blocks can function very well and really be durable, if the walls are provided with a proper foundation, a sufficient roof overhang and a suitable surface covering.

The CSSB-technology has, during the last years, spread in some urban areas, mainly in Addis Abeba.
According to [Asplund (1997)], the first building erected with cement stabilised soil blocks (CSSB) in Ethiopia was a school building in Jinka, about 800 km south of Addis Ababa. This building, which was built in 1968, is still in use, and in good condition, although according to [Andersson (2003)] the walls were not plastered, either externally or internally. The walls were provided with reinforced tie-beams and the building had a normal overhang.
The possibility to use AB or CSSB technology seems thus, from a technical point of view, to be good. This conclusion is furthermore underlined by the results from a minor research project on the BSc level, "*Low cost housing for the Kambaata Region, Ethiopia*" [Andersson and Berglund (2002)] that was carried out at Halmstad University in 2002. Based on field studies and field tests in Kambata, this degree project showed that from a technical point of view it is possible to use e.g. stabilized soil blocks as a building material in the region.

Affordability – cost limits

The introduction of a new house building technology must of course also take into account economic realities. If this introduction is intended to benefit ordinary people, they must afford to build a house according to the new technology.

What can ordinary people, e.g. in Durame, afford as regards building their own dwelling house? It is of course impossible to answer this question directly and generally. However, some light can be shed upon this issue by results obtained from the abovementioned study. The 50 selected house owners were asked to estimate how much it cost them to construct their house. Their answer varied between less than 10,000 ETB (Ethiopian Birr) to more than 60,000 ETB. (1 ETB = approx 0.115 USD at present). Based on this information Table 3 has been compiled. In addition to this the sizes of the houses belonging to the randomly selected 50 house owners were estimated. The result is presented in Table 4. Finally, the sizes of the different households living in the dwelling houses were registered; see Table 5.

Table 3. Estimated construction cost ((1 ETB = approx 0.115 USD at present).

Cost (ETB)	Frequency	Percentage
< 10.000	18	36
11.000 – 20.000	17	34
21.000 – 30.000	6	12
51.000 – 60.000	3	6
31.000 – 40.000	2	4
41.000 – 50.000	2	4
> 61.000	2	4
	50	100

Table 4. Estimated size of dwelling houses.

Size (m^2)	Frequency	Percentage
31 – 50	9	18
51 - 70	8	16
71 - 90	12	24
91 – 110	15	30
111 – 130	3	6
131 -	3	6
Total	50	100

Table 5. Sizes of households.

Size of household (persons)	Frequency	Percentage
1 – 3	1	2
4 – 6	16	32
7 – 9	20	40
10 - 12	11	22
13 -	2	4
Total	50	100

Table 3 shows that by estimation the cost of erection of about 80% of the dwelling houses in Durame was less than 30.000 ETB. This figure indicates the very low cost levels that must be obtained if an introduction of a new technology shall have the desired impact.

Table 4 shows that more than 50% of the dwelling houses in Durame has a size of 71 m^2 or more. This indicates that it will be very difficult to introduce and have accepted dwelling houses which are too small. It seems that the size 71 m^2 is a minimum size. The information obtained from Table 5 is apparently linked to this issue. Table 5 shows that about 60% of the house-holds include 7 – 12 persons.

The conclusion of the combined information obtained from Tables 3, 4 and 5 is that Adobe Blocks must be the main material for walls. In most cases it will be impossible, of economic reasons, to use Cement Stabilised Soil Blocks.

In addition to this it can be stated that the introduction of this new house building technology should be greatly enhanced if working with Adobe Blocks could be accepted and regarded as "everybody`s property". However building houses from mud and working with clay has low status in Ethiopia. In other words social stigma is attached to working with clay or mud which makes it necessary to take into account the attitudes towards this new technology.

Attitudes
As described earlier the pre-study comprised both a literature survey and a number of interviews. Both the literature survey and the interviews have underlined the fact that there are several obstacles related to attitudes in connection with the introduction of a new house building technology. The obstacles which can be considered to be the most important, are discussed below.

Prejudices and reluctance
Mud is not a new building material. On the contrary it has been used for centuries in many parts of the world. [Agarwal (1981)] argues that "*Of various types of traditional building materials available mud is the most widely used and will remain so long into the foreseeable future*". However, as other building materials have been developed mud has lost its position as the natural building material. As a consequence, soil stabilised as building material is very often seen as low quality material and it is associated with poverty. This in spite the advantages that mud has as a building material: low cost, low energy consumption, low transportation cost and environmental soundness. Even if mud has these advantages as a building material, it is obvious that researchers, house planners, governments, banks and individual house builders had not given attention to its development.

A common reason for reluctance to use soil block technology seems to be uncertainty about the strength and durability. [Rydland (2003)] expressed it as follows: “*Most of the people (in Ethiopia) we deal with have a retrospective perspective on their doings. They replicate rather than invent, simply because replication is much safer.”* As a consequence many would choose to "wait and see", rather than taking a risk. According to [Rydland (2003)]ordinary people generally live on a very narrow margin and dare not to take the risk involved in using a new, unknown, technology.
Stigmatization
The pre-study study has shown that a building material/adobe based on soil-straw combination has bad connotation. [Gooding and Thomas (1995)] states: *"Sandcrete use is widespread and increasing: it has good popular image. Soil-cement by contrast carries an association or stigma linking it with un-stabilized soil and simple adobe construction which has much limited its popularity*." They further explain a change of attitude as a result of demonstration undertaken in countries like Tanzania, Kenya, Ghana etc. In their view, even if soil-cement blocks cost 30% less than sandcrete walling by using low-pressure production, it may not encourage the uptake of the technology due to social stigma.
A proper communication with words and action is important to encounter against possible stigma attached to mud technology. [Rydland (2003)] has stressed that “*making a low-cost housing technology acceptable is a matter of words, communications and attitudes more than knowledge about how to build a house*”.

Insecurity
One factor that could be decisive for people avoiding to use stabilised soil blocks or adobe blocks could be the uncertainty to the strength and durability. "*It is easy for thieves to break it* " is a comment that can be heard when people talk about adobe blocks. Anyhow, according [Johansson (2003)] this fear is strongly exaggerated. The question of security must however be taken into consideration in a serious way when the material shall be developed and tested.
Status
The choice of a building material is always a matter of function, strength, durability or price. But many times it is also a matter of social status. In Ethiopia not only building houses from mud but also working with clay has low status. In other words social stigma is attached to working with clay or mud. As stated by [Agarwal (1981)] "*Status is at the root of the problem of non-acceptance. Mud houses are associated with poverty*".

CONCLUSIONS FROM PRE-STUDY: IMPORTANCE OF AWARNESS BUILDING AND NEED OF DEMONSTRATION PROJECTS

The pre-study has clearly shown that the attitude of the potential users is a very crucial point in connection with the introduction of a new house building technology. Factors such as prejudices and reluctance, stigmatization, insecurity and status are important and must be taken into account in connection with the planning, launching and implementation of a low-cost housing project. Our hypothesis is that two important measures can be taken in order to overcome these obstacles. These two measures, which preferably could be used in combination, are awareness building and the use of demonstration buildings.

According to information in available literature awareness building plays very important role in the process of introducing a new technology. [Holmqvist and Rehnström (1992)] states: "*The scepticism among the population to use non-traditional building materials can be removed by spreading information about advantages. Participation from the tenants during construction leads to increased knowledge and responsibility*."

The intended new technology can be communicated by words as well as by giving practical examples. In this context demonstration buildings can be a tool by which the attitudes towards the new technology can be changed in a positive direction.

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Foresight Studies and Reform Initiatives in Construction: Lessons for Developing Countries

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Abstract
This paper analyses construction foresight studies and construction reform initiatives with a view to identifying lessons for developing countries. It notes the number of construction reform initiatives over the last 60 years, mostly in the developed countries, aimed at reforming the domestic construction industry, and equipping it to be globally competitive. The paper argues that although these studies contain a wealth of knowledge, they are prepared in the context of circumstances unique to developed countries. The paper then distils the lessons from these studies, contextualizes it and makes some observations relevant to a developing country's unique circumstances and challenges. The paper will analyze foresight studies relevant to construction identifying commonalities; analyze global construction reform initiatives identifying commonalities; collate the consistencies and identify issues critical for comparable studies in developing countries; and posit conclusions and recommendations for construction development initiatives in developing countries.

Keywords
Construction, foresight, industry development initiatives, technology, governance

INTRODUCTION

Background

A number of construction industry development initiatives have been undertaken in the past. In the United Kingdom, at least 23 reports have been produced since 1944. The UK reports include the *Simon* report [1944], *Phillips* report [1948-50], *Emmerson* report [1962], *Banwell* report [1964], *Tavistock* reports [1965, 1966], *Large Industrial Sites* report [1970], *Wood* report [1975], *Faster Building for Industry* [1983], *Wells* report [1986], *Faster Building for Commerce* [1988], *Latham* report [1994], *Levene* report [1995], *Egan* report [1998], *Achieving Excellence* [1999], *Achieving Sustainability in Construction Procurement* [2000], *Building a Better Quality of Life* [2000], *A Commitment to People: Our Biggest Asset* [2000], *A Vision Shared: The Movement for Innovation* [2000], *The Housing Demonstration Projects Report: Improving through Measurement* [2000], *Rethinking Construction* [2000], *Better Public Buildings: a Proud Legacy for the Future* [2000], and *Accelerating Change* [2002]. More recently, however, the construction sector in other countries have produced their own reports, including *Vision 2020* [2004] in Sweden, *Finnish Real Estate and Construction Cluster's*

Vision for 2010 [2001] and *The Construction Industry Technology Strategy* [2001] in Finland, *Construction 21* in Singapore [2002], *Construction 2020 – A Vision for Australia's Property and Construction Industry* [2004] in Australia, and most recently, the *Inventory of International Reforms in Building and Construction* [2004] in the Netherlands. A *Status Report on Building Culture in Germany* [2001] has also been undertaken, but this report differs in that its focus is the value of a well-built environment. In addition, the International Labour Organisation prepared a report *The Construction Industry in the Twenty-first Century: Its Image, Employment Prospects and Skill Requirements* [ILO: 2001] that focuses specifically on employment issues within the constructors sub-sector. A recent addition to this body of reports is the preparation of foresight studies for the sector. Unlike the reform initiatives that identify current failures with a view to introducing interventions aimed at correcting or minimizing the failures, foresight studies aim to determine a number of future scenarios that can enable the sector to respond more effectively to future events. These reports include *Technology Foresight* report [1995], *Technology Foresight Ireland* [1998], *UK Construction 2010 – the Future Trends and Issues* [1999], *Adopting Foresight in Construction* [1999], and *Foresight: Constructing the Future* [2001].

Need

While the foresight and construction industry development reports identified above were produced in and for developed countries, the construction sector in developing countries experiences similar failures and faces similar challenges to developed countries. In addition, the economies of developing countries have other specific challenges relating, inter alia, to resource, technology and skill scarcity, and high levels of poverty and unemployment. A comparative analysis of foresight and reform studies can offer guidance to developing countries wishing to improve the performance of their construction sector.

Purpose statement

This paper analyses the findings of construction sector foresight and reform reports prepared for developed countries, extracts lessons for developing countries, and prepares observations, recommendations and conclusions relevant to developing countries.

Scope

This paper is limited to the review of specific foresight studies and reform initiatives as more fully described in the section on methods and materials. The paper did not investigate the methodologies used to prepare the reports in either case.

Definition of Terms

For purposes of this paper, the following definitions are used.
Construction sector – "*The Construction Sector comprises establishments primarily engaged in the construction of buildings and other structures, heavy construction (except buildings), additions, alterations, reconstruction, installation, and maintenance and repairs. Establishments engaged in demolition or wrecking of buildings and other structures, clearing of building sites, and sale of materials from demolished structures are also included. This sector also includes those establishments engaged in blasting, test drilling, landfill, leveling, earthmoving, excavating, land drainage, and other land preparations. The industries within this sector have been defined on the basis of their unique production processes. As with all industries, the production processes are distinguished by their use of*

specialized human resources and specialized physical capital. Construction activities are generally administered or managed at a relatively fixed place of business, but the actual construction work is performed at one or more different project sites" [CETA, 2004].
Foresight – The definition of Foresight used is that by Averil Horton [1999], "*Foresight is the process of developing a range of views of possible ways in which the future could develop, and understanding these sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow*."
Industry Development – The Construction Industry Development Board (CIDB) of South Africa defines industry development as "*the deliberate and managed process to optimize the contribution of the construction industry in meeting national construction demand, in promoting national social and economic development objectives, industry performance and competitiveness, and improved value to clients and society*" [Milford et al, 2000].

METHODS AND MATERIALS

How Raw Data was Obtained

Raw data was obtained from a desktop and literature review of the following specific reports: the *Latham* report [1994], the *Levene* report [1995], the *Technology Foresight* report [1995], the *Egan* report [1998], *Technology Foresight Ireland* [1998], *Achieving Excellence* [1999], *UK Construction 2010 – the Future Trends and Issues* [1999], *Foresight: Constructing the Future* [2001], *Construction 21* [2001], *Finnish Real Estate and Construction Cluster's Vision for 2010* [2001] and *The Construction Industry Technology Strategy* [2001], *Accelerating Change* [2002], *Vision 2020* [2004], *Construction 2020 – A Vision for Australia's Property and Construction Industry* [2004], and the *Inventory of International Reforms in Building and Construction* [2004].

How Data was Interpreted

The data was collected and categorized according to the notion of the five types of capital devised in the *Brundtland* report [Edwards, 2002], i.e. economic, social, environmental, technological, and ecological, and a comparative analysis undertaken to identify commonalities and dissimilarities.

AN ANALYSIS OF FORESIGHT REPORTS IN THE CONSTRUCTION SECTOR

An analysis of the findings of construction foresight reports, categorized in accordance with the sources of global resource that require skillful management, highlights the impacts, with probable responses, that possible future developments could have on the construction sector.

Economical Capital

- The decrease in the public funding of infrastructure is likely to continue even though present demand and indications of future growth in population requires an increase in construction outputs, specifically housing. The consequence hereof is a continued deterioration of public infrastructure.
- The sector is likely to come under increasing pressure to integrate the planning of total infrastructure demand, to respond to procurement policies that allow for margins of research and development, and to operate in an efficient and holistic regulatory environment

- The built environment will comprise much of what already exists, focusing the construction sectors attention on maximizing and exploiting the re-use of buildings.
- There will be an increasing recognition of the role of buildings and space as productive assets resulting in a strong emphasis on adding value through design. Designers will need to design facilities that are capable of deconstruction and reuse. Increasing land use restrictions will require the planning of buildings and infrastructure to be more efficient.

Social Capital

- Structural changes in developed societies are due to the shift from an industrial society to an information society, progressive globalization, rapid urbanization, demographic changes and an increase in the number of households and in individuality. These structural changes, driven in part by the revolution in computers, are driving a growing demand for life-time education, skills and training. Future business enterprises will be highly dependent on information sharing, customer-centric thinking, electronic commerce, and co-operation and integration at every level throughout the supply chain. These issues together may increase the risk of inequality and social exclusion, placing greater demands on the quality and efficiency of infrastructure.
- Construction will have to offer more attractive employment in an industry increasingly subjected to external competition. The sector will have to provide healthy, safe and attractive employment conditions that include lifelong education and training together with obligatory registration of the principal parties to the process.
- Customer and society's expectations for efficiency, quality, performance and life-cycle value will drive the competitiveness of the sector. A greater public appreciation of the value of infrastructure to social and economic development must be engendered. To do this, a culture of quality and excellence must be built, using the best technology and being innovative in producing infrastructure that also produces affordable housing and meets the special needs of the economy and an ageing population. One report called upon Government to support the inclusion of construction and infrastructural elements in the curricula of primary and secondary schools.
- The construction sector must be ready and capable to meet the anticipated huge demand for housing.
- The design of construction products in the future will be focused on a specific function and duration with in-built structural flexibility. Design will need to be based on empirical analysis of the client's situation with a concomitant massive increase in design inputs.
- There is a view that construction will need to develop and sustain the tradability of knowledge based and niche elements of construction.

Environmental Capital

- The threat to the sustainability of the physical environment is recognized and the conservation of non-renewable resources, environmental protection, and the destruction of cultural heritage are keywords for the future. A progressive improvement of the contribution to the inherent sustainability of the construction process and the built environment will require the development of associated technologies, skills and practices.

Technological Capital

- The sector will need to become and be perceived to be a competitive state-of-the-art 21st century industry capable of producing efficient and sustainable infrastructure. This requires the promotion of smart buildings and infrastructure. New technologies, intelligent products, standardized, pre-assembled components and advanced materials will be in greater demand. A shift toward more industrial-type product manufacturing is generally expected. The use of bio-and nanotechnologies in the future is predicted.

- In lieu of the growing importance of science, technology and innovation, consideration must be given to the establishment of some form of permanent centre/focus for accessing and transferring of new best practice technologies, with a strong element of industrial ownership.
- Information and Communication Technology (ICT) will be a powerful technological driving force providing customized and integrated information technology throughout the construction process is predicted. A rapid advancement of technology-driven thinking and practice across the whole lifecycle of facilities is predicted.
- Construction will need to track and optimize the benefits of advances in materials technology to construction and infrastructure in order to satisfy the demand for materials that offer improved performance overall.

Ecological Capital

- Climate change will have a significant influence on the production processes of the entire supply chain of the construction sector.

AN ANALYSIS OF CONSTRUCTION INDUSTRY DEVELOPMENT INITIATIVES

An analysis of the findings of construction industry development initiatives, categorized in accordance with the sources of global resource that require skillful management, highlights interventions construction should instigate to in response to past failures.

Economic Capital

- Set performance targets for the sector. Targets should be aimed at reducing capital costs, defects, accidents, improving construction time, predictability, productivity, and turnover and profits.
- Use procurement to drive behavior within the sector. This requires, inter alia, greater professionalism in procurement, public and private, to inculcate good governance practices, i.e. standards of capability, performance and behavior. The adoption of more integrated approaches to procurement including non-price factors in evaluation, the adoption of life-cycle costing or moving in the direction of concession i.e. design-build-operate contracts, and the selection of consortia for ‘programmes’ of projects, rather than single projects, is urged. Government is requested to adopt a more commercial approach, including the negotiation of contracts on the basis of value for money.
- There are significant opportunities for construction to engage in global markets provided the sector can improve its competitiveness.
- Improve the service to the housing market. Construction must focus on improving the products delivered to the housing market, improving the quality of housing, increasing the flexibility of housing and the development of housing-related services and conservation, especially through the use of new technology in production and service processes
- There are huge opportunities for construction in the refurbishment sub-sector and construction should exploit these opportunities.
- Standardized construction contracts are desired. Such contracts should deal with issues of clarity, fairness, roles and responsibilities, allocation of risk, payment, and better guidance on best practice and legislative changes to simplify dispute resolution and to ensure prompt payment. Short duration contractual relationships are preferred. The sector is urged to promote a single contract.

Social Capital

- Leadership must be provided at all levels throughout the entire construction sector. This includes improving management, showing leadership in the creation of integrated teams, single point of responsibility, partnering, changing relationships, and framework agreements.
- Trust must be restored. Interventions include the use of Codes of Practice and Codes of Ethics, and the development of a common vision for and of the sector. The common objective is to improve the image and overall stakeholder satisfaction with the industry. The sector must accept responsibility for the services delivered, and ensure that they are cost-effective throughout the whole life of the facility.
- Registration and pre-qualification mechanisms are required. Constructors must apply for formal registration against a set of criteria, and pre-qualify before submitting bids.
- Professionalism in the sector must be strengthened. Suggested interventions include enhancing the tertiary curriculum for construction-related studies and aligning design courses with industry needs. Continuing professional development should be obligatory.
- A quality-driven agenda is necessary. This requires the building of a culture of continuously seeking improvement.
- A commitment to people must be made. This requires improvements to the total working environment through, inter alia, the better management of the effects of adverse weather and more off-site prefabrication, improving the health and safety of workers, introducing lifelong training, placing the welfare of the labour force at the centre of the production process, developing a computer literate and highly skilled workforce, showing mutual respect for each other through management and workers acting collaboratively.
- Construction must focus on the customer. The sector is urged to meet clients' needs, including current project initiators, future owners and tenants. The sector should provide a superior quality of customer service through integrated approaches in the delivery process, including design, throughout the whole sector. The fragmentation of responsibilities must be stopped to enhance customer-driven operations and overall efficiency, and to add value to the entire customer chain.
- Redefine the roles of associations and of new information systems, of research, and of regulations. Their role should enhance the development of high standards in the industry.
- The sector must broaden its focus on design. Design decisions should take into account factors such as adaptability of spaces, structural and material life expectation, maintenance demands, fitness for purpose, health and safety, energy and environmental impacts. The design phases should be reworked to support and integrate packaged technical solutions.
- The role of construction industry boards is supported.
- Governments should commit to be a best-practice client, particularly with regard to the preparing of realistic budgets and timetables. Government officials are urged to develop a proper understanding of risk and therefore risk management.

Environmental Capital

- There is a real need for environmental responsiveness**.** The sector must develop construction products that are energy-efficient, buildings that are classified on environmental grounds and that use new innovative systems for energy production, distribution and consumption, and support extensive research and development investment in sustainable development. Facilities should be whole-life planned, and sustainable construction should include reducing environmental impacts through recycling and material conservation should be added.

Technological Capital

- The sector must establish strategic partnerships to supply sub-assemblies and constructors should strengthen partnering in the supply chain. The product team must be integrated. The sector must achieve single point responsibility from the facility supplier.
- There is a need for new production systems. These systems could include product development, the commercial packaging of products, building components and systems for buildings, off-site manufacture, lean manufacturing, and IT.
- There is significant potential to add value through the embedding of ICT. The sector can add value to premises throughout the delivery chain, from using 3-D modeling throughout the design process to real time contract documentation updating to modeling whole lifecycle of buildings. State-of-the-art information technology and management should be used to undertake construction and product model-based construction design, production and procurement, storage, maintenance and utilization of building product data during the various stages of the facility, intelligent materials, and the employment of monitoring sensors able to communicate whole life performance. Construction should maximize the construction-related business opportunities contained in the use of wireless communication, a variety of applications of e-infrastructure, energy infrastructure, fault tolerance under demanding conditions and the construction of infrastructure for extreme temperatures.

Ecological Capital

- Construction should minimize negative impacts on the natural environment and preserve environmental choices for future generations.

LESSONS FOR DEVELOPING COUNTRIES

In analyzing the interventions suggested in the reports, the following lessons are extracted.

1. Understand and appreciate the role of the sector. This notion recognizes that the physical infrastructure that constitutes the built environment, also underpins human development, is crucial to the economic development of any country – especially developing economies – and is a fundamental component to poverty reduction. In the main, the onus is placed on owners, particularly at government level, to realize that an efficient and profitable construction sector is a key fundamental for national success. However, users too should appreciate the value of infrastructure to their social and economic development. Construction sector participants can make this appreciation more immediate by maximizing and exploiting the effective and efficient re-use of buildings, and by paying particular attention to meeting the housing demand and improving the performance of housing.
2. Establish a shared vision. The core component of the vision should be to make the sector a state-of-the-art 21st century industry.
3. Devise strategies and structures for change. Revisit the respective roles of official and industry associations (including academe and research institutions), strategy preparation and communication, and how individual stakeholders can participate in the change process.
4. Use procurement to drive behaviour. Examine the degree to which procuring bodies can shape industry performance through their ongoing purchasing power, including new contractual and financing systems, the balance between imposed and negotiated requirements, and the entire supply chain delivery process.
5. Monitor and evaluate change. Introduce a monitoring system to determine the extent to which the objectives are being met, and include benchmarking and indicators in its application.

6. Strengthen the regulatory environment. Introduce statutory controls to drive behaviour, although some markets are less amenable to government intervention than others.
7. Recognize the value of human capital. The vision must recognize the need to greatly advance the depth of human capital within the construction sector, and should advocate a number of strategies aimed at attracting skills, encouraging change, training for change, and creating a safe and healthy workplace conducive to innovation and improved productivity.
8. Recognize the value of environmental capital. Although the sustainability of the construction sector and reducing the environmental impacts of construction are common concerns to all the reports, clearly define and separate the two concepts.
9. Recognize the value of technological capital. Recognize the need for the sector to become more innovative and to a greater or lesser extent look to technology as the vehicle. Understand the differences with regard to which technologies these should be, but note the drive toward the greater use of off-site assembly and a more industrially-orientated process. This includes the promotion of smart buildings and infrastructure, new technologies, intelligent products, standardized, pre-assembled components and advanced materials.
10. Step up research and development. The focus of the research and development agenda can vary, and include the current interest in technologies such as biotechnology and nanotechnology.

However, there are a number of observations pertinent to industry development initiatives that are critical to improving the performance of construction in developing countries and that were not included in the initiatives analyzed.

1. Confirm the need for change. This truism requires the construction sector to shift its core focus from process-dominated (supply-side) interventions to product-orientated (demand-side) interventions. For developing countries it is imperative that the beneficiaries of construction sector performance improvements be extended to include society. Include the full structure of the construction sector in industry development initiatives: the structure of the construction sector – and those who add value to it – extends very deeply into the societal fabric of a community. A useful guide to test for inclusitivity is to refer to the definition of the construction sector included in this paper.
3. Construction development initiatives must be solidly founded on the principles of good corporate governance, should commit to corporate social responsibilities practices, and abide by a sector-wide code of ethics and code of practice. Although most reports included codes and best practice, the best practice culture (thinking the best and behaving the best) was not linked to good corporate governance. Concomitant issues relating to leadership, professionalism, respect for people, partnerships in the supply chain, integrated teams, and fair contracts are all derived from this foundation.
4. Not surprisingly, the initiatives reviewed fail to address the challenges central to developing societies, and the role of construction in addressing those challenges. However, many of these challenges are central to constructing the future, including recognizing construction’s role in contributing to the knowledge economy, developing skills to shape tomorrow, understanding the Millennium Development Goals, directly facing the human rights abuses inherent in contemporary construction practices [ILO: 2001], ending discrimination against women in the sector, improving job quality, engaging with the social issues surrounding the Diaspora including enhancing social cohesion, contributing directly to reducing global warming, and responding to the HIV/AIDS pandemic. Construction has the ability to cross the divide between the first and second economies by employing the disempowered, developing their skills through on-job training, fostering social cohesion, and building an environment that enhances the economic, social and environmental quality of life.

CONCLUSIONS AND RECOMMENDATIONS

Many other industrial sectors, manufacturing in particular, have undergone significant structural changes and product creation improvements. By contrast, the construction practices remain firmly rooted in the building tradition of the Mesopotamian Era. The sector remains configured on the traditional model in which laborers, trades-people, professionals, and clients work in short-term, lowest-offer contractual arrangements that present high financial risk and show a low respect for people, delivering poor quality, over budget and time, with a propensity for legal action. In responding to this challenge, essentially two approaches are available. The first aims to correct past failures, while the second aims to deliver construction outputs that meet future demands. Few manufacturing activities are more future-sensitive than construction. This is because construction outputs, quite distinct from other manufacturing outputs, have such an extraordinary long life. It is therefore critical that industry development initiatives shift the core focus from process-dominated (supply-side) interventions to product-orientated (demand-side) interventions, making full use of new skills and technologies. In summary, strive to do what is right, and then do it in the right manner.

It is recommended therefore that construction sector development initiatives be responsive to the environment in which it operates, both now, and for the likely future. This also happens to be the fundamental principle of good corporate governance and corporate social responsibility. Ultimately, we can conclude that construction sector development initiatives must strive to confirm the legitimacy of construction, i.e. by committing to a new paradigm based on the proper understanding of technology and the principles of good corporate governance.

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SER APTO – Sustainable low-income Housing on Brownfield site

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Abstract
Brazil currently possesses a deficit of 10 million habitations for low-income population. In São Paulo we perceive an increasing expansion of the urban site conditioning irregular settlements in water supply protection areas. This work proposes the creation of a sustainable low-income housing on a Brownfield site in the city of Santo Andre, by the environmental revitalization of degraded areas and use of generated resources in its the operation. The environmental diagnostic was performed and proposals for remedy recommended. The project program took in account the essentials of the dignity human beings, instead of the usual minimum cost and maximum occupancy. For the definition of the project it was employed radiesthesia, golden ratios, analyses and simulation of natural lighting and solar thermal control, natural ventilation, accessibility, specification of technologies and materials with the least environmental impact and references to the architecture of Brazilian vernacular. For the operation it was proposed treatment and reuse of storm and grey waters, recycling of residues and water heating by solar energy. The project still depends on systemic approach of implantation and operation as a sustainable solution in great urban centers, having this model the reproducibility as a marked characteristic for transferability to great metropolises.

Keywords
Sustainable construction; Brownfield revitalization; social housing; environmental aspects of construction, systemic approach

INTRODUCTION

New Paradigms

Kerala, a state of the southwest of India, has been object of international studies because it presents indicators of high quality of life, some of them superior to the ones seen in developed countries. In this regard, one important aspect is the capability of the population's participation in the governmental deliberative instances [Evans, 2003]. Another very important aspect is the possibility of attaining maximal results with few resources, by prioritizing definite values as essential to the community. It is important to recognize the positive experience of Kerala because the world population is increasing while the resources are decreasing.

For the elaboration of this project it was proposed to rescue the essentials to the dignity human beings, prioritizing communitarian spaces, instead of the usual minimum cost with maximum occupancy practiced in the effective social-housing government programs. It was used as references the successes obtained in the scope of the social housing movements, claims of local communities and lines of direction of the Managing Plan of the City hall of the City of Santo Andre had been used as reference.

For the construction, it was specified sustainable materials and technologies, which, although they raise its costs, in its run the enterprise will produce financial return.

The project team, composed of eleven professionals of different areas, was inspired in new organizational paradigms based on dialogue [Bohm, 1989], appreciative inquiry [Cooperrider (1987), Cooperrider, Srivastva (1987)], self-management [Jantsch, 1980] e learning organization [Senge, 1990].

URBAN GROWING AND THE BROWNFIELDS

The **SER APTO** site is located in one of the most important areas of industrialization in the Sao Paulo metropolitan area. The industrialization process started in the 1940s by currently the industries have been de-commissioned, leaving as sequels the environmental liabilities (figure 1).

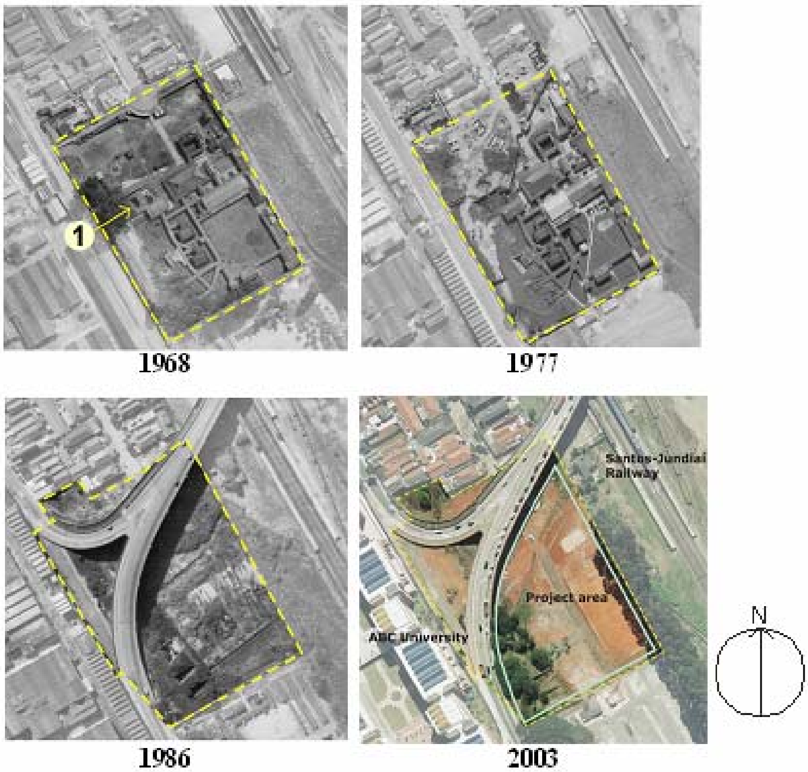

Figure 1 – Historical use of the area since the decade of 1960

These liabilities in the urban centers generate abandoned areas that possess all the necessary infrastructure, the so called **brownfields,** while concurrently there is an expansion of the urban sites with the development of slums in the peripheries that reach preservation areas, such as the main water supplies of the population.

Revitalization of degraded areas including remedy of the soil and groundwater by removal of hot spots and pumping and treatment of contaminated groundwater, constitutes technological viable solutions that will allow a safety occupation of these areas.

The **SER APTO** project was developed to be implemented in the City of Santo André - SP, Brazil. In accordance with the Territorial Ordinance of the municipality, the area of the project is classified as a Special Zone of Social Interest, called C ZONE, which is characterized for abandoned properties and underutilized areas for low incoming houses.

OBJECTIVE

The objective of the project is to demonstrate the application of lines of direction and methodologies in urban enterprises as tools for public entrepreneurs and government managers, by specifications of materials, sustainable technologies and operations, and search to minimize the impacts usually generated in traditional constructions.

ENVIRONMENTAL ASSESSMENT AND REMEDIATION

The preliminary assessment of the site showed presence of alterations in the quality of the soil and groundwater, thus confirming the existence of environmental liabilities.

The assessment of the environmental situation included: characterization of historical evolution of the occupation of last the four decades by the analysis of aerial photographs of the area and the outskirts; determination of the hydrogen ionic potential and electric conductivity of the superficial portion of the soil; soil gas survey; geophysical survey with GPR (ground penetration radar) and ER (electroresistivity); soil and groundwater sampling in pre-determined points (figure 2) and the radiesthesia methods applied to the deepest portion of the water-bearing one

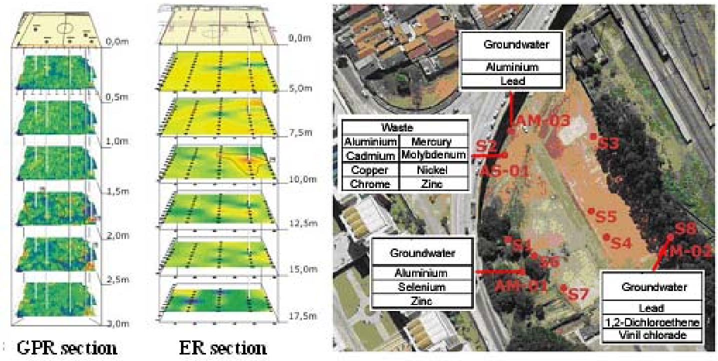

Figure 2 – Alteration of quality in the soil and groundwater

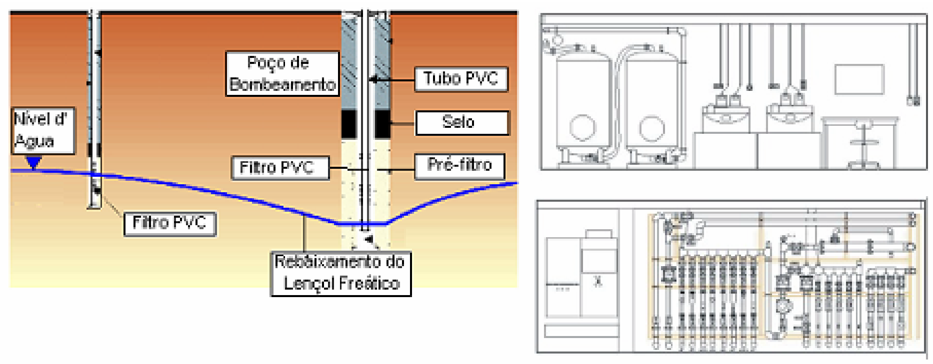

Figure 3 – Proposed remedial measures – Pump & Treat system

The results indicated alterations in the quality of the soil and the shallow groundwater. The recommended remedial actions are the removal of wastes and the pumping and treatment of shallow groundwater for the restoration of the environmental quality to allow the future use of the property without restrictions (figure 3).

DESIGN CRITERIA

The design criterion proposed is the verticalization of the buildings in order to leave more permeable surface and leisure areas, and elevators to allow accessibility to all floors of the building.

The total area of the undertaking is 10,000 m2. The project predicts three blocks of apartments with twelve floors, four blocks with nine floors and three blocks with seven floors, totaling up 186 housing units with a constructed area of 15,500 m2, and 5,500 m2 of common areas. The area under the viaduct was destined to the social equipments for both population of the condominium and adjacent community (figure 4).

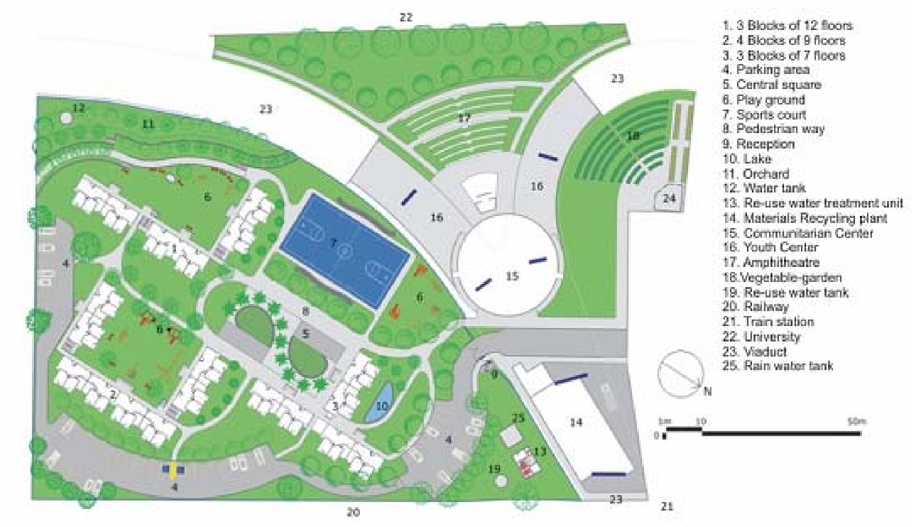

Figure 4 – Lay out of the implantation – SER APTO Project

During the project conception for both external areas location as well as housing units design, it was utilized radiesthesia, golden proportions, universal design criteria (figure 5), and environmental comfort with sunstroke and shading studies, natural ventilation (figure 6) to allow people with physical disability access to all spaces.

In order to define the materials and technologies descriptive new criteria were established, in addition to low-cost considerations: comparative analysis of products, life cycles analysis, energetic efficiency performance, economy of natural resources and evaluation of manufacturers´ behavior valuation within the context of sustainable.

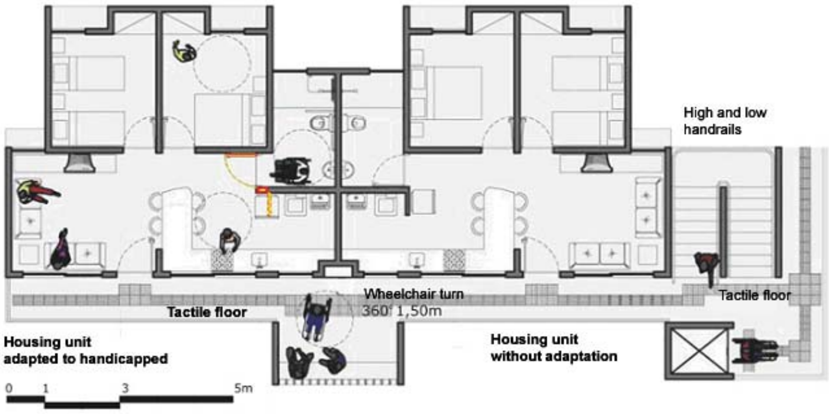

Figure 5 – Accessibility for all the espaces of the building

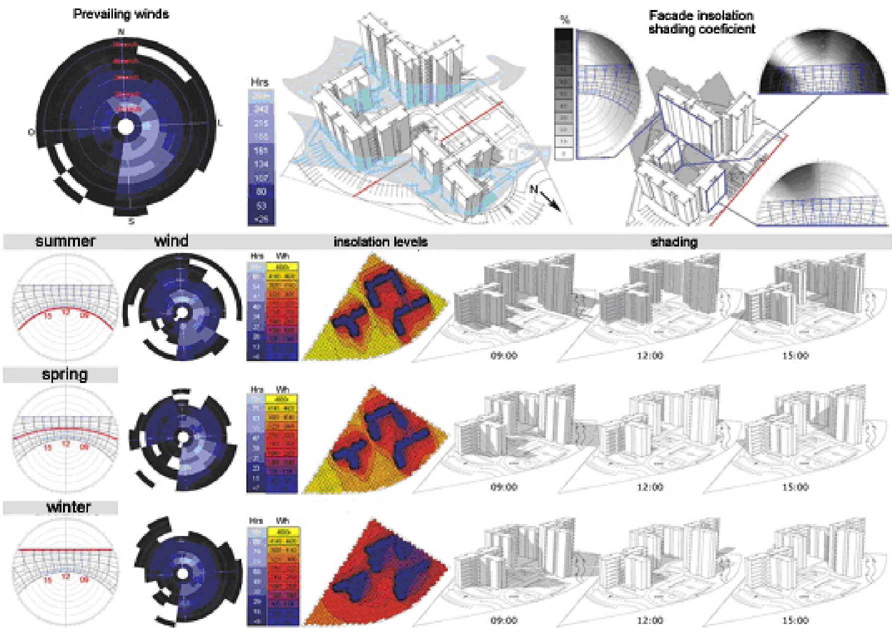

Figure 6 – Computer simulations for definition of natural lighting and solar thermal control - environmental comfort

In addition to prior designation of transporters and qualified addresses for possible recycling, it was developed a project of residues' management involving characterization of the residues, description of conditions for selection and packaging.

SUSTAINABLE CONDOMINIUM OPERATION (figure 7)

Materials Recycling Unit and Organic Compost

In order to make feasible the implantation of recycling unit, it is necessary to extend this benefit to the adjacent community which comprises approximately 100 families, that will generate a total of 144 ton/year (12 ton/month) of recyclable materials and a consumption of 168 ton/year (14 ton/month) of organic material that will be destined to organic compost.

Water reuse and treatment unit

The project of the grey water treatment station to be collected of washbasin, showers and rain water was developed in order to use the treated water for non potable uses like garden irrigation, common areas washing and for toilet flushing.

The grey water treatment unit chosen consists of a biologic treatment of the effluent previously decanted that represents high-efficiency power of degradation of organic burden and low-cost energetic. It is a system based on degradation carried out by microorganisms living in the drainage with low generation of residual mud.

Water heating by Solar Energy

The conception of the water heating by solar energy system for the project considered many data got obtained from experiences of different condominium housing introduced in Brazil.
A daily total of 31,500 liter of water will be heated to 50^{o} C for all the 186 housing units that will be stored in 3 central boilers provided with individual consumption meter.

PERSPECTIVES

For the implantation of a conventional undertaking introduction, one notices a linear vision process in which the material resources, from the origin to their discharge, are not normally questioned. During the operation, no one questions about the source of energy and natural resources generating residues in large volume for the sewerage system and many materials for landfill.

This project proposes a systemic approach (figure 8) contemplating all aspects involved, along with its life cycle, from conception of the project, to implementation and operation, that will show viability in a modern vision of sustainability.

The viability of the undertaking, which proposes the connection of all the aspects mentioned, underscores the perspective of the existence of sustainable cities inserted within the natural cycles of the Earth [Capra, 1996]. The perception that the city is not part of Nature constitutes one more paradigm to be broken by the society.

WASTE RECYCLING

GENERATION PROFILE
Condominium - income til 6 minimum salaries. Waste generatiom 750 hab 274 ton/year

200 local families - income til 10 min. sal. Waste generation 850 hab 310 ton/year

Organic Compound generation 64 ton/year

WASTE PROFILE
Generation of 188.160 Kg/year of recyclable materials

SOCIAL AND ECONOMIC ACCOUNTING
Resource generation by operation of separation and recycling of materials

pay back by unity

Economic Social valuation

6 direct post of work

Implantation	R$90.000
Investment	R$120/hab
Oper. cost	R$28.000/year
Income	R$63.500/year
Balance	R$35.500/year

WATER RE-USE

CONSUMPTION PROFILE
Condominium - 750 habitants
Sewerage generation
75 m3/day 27.375 m3/year
Gray water generation
37,5 m3/day 13.687 m3/year
Rain water captivation
5 m3/day 1.275 m3/year
Good use of 75%
3,7 m3/day 956 m3/year

PATTERN OF USE
Captivation of gray water of shower, lavatory basin and tank. Aerobic treatment desinfection by chlorination. Re-use in sanitary, irrigation of green areas, lake and car and floor cleaning.

SOCIAL AND ECONOMIC ACCOUNTING
Generation of resources by reduction of water demand, re-uso of gray and pluvial water.

pay back by unity

Economic Social valuation

2 direct post of work

Implantation	R$150.000
Investment	R$200/hab
Oper. cost	R$14.500/year
Income	R$67.000/year
Balance	R$52.500/year

SOLAR WATER HEATING

CONSUMPTION PROFILE
Water heating for 186 showers.

SPECIFICATION OF USE
Heat water volume:
3 boilers with 4m³ (Blocks 1 e 2);
2 boilers with 4m³ (Block 2)
Coletores: 60m² - Block 1; 60m² - Block 2; 36m² - Block 3
panels with 2x1m, approximately 156m² Heating capacity of 37,5 m3/day of 25 a 40 °C water.
Availability of 50L/bath habitant.
Collective boiler system with individual remote monitor.
Heating complement by electric energy in the boiler

SOCIAL AND ECONOMIC ACCOUNTING
Resource generation by reduction of electric energy demand.

pay back by unity

Economic Social valuation

1 direct post of work

Implantation	R$390.000
Investment	R$525/hab
Oper. cost	R$8.000/year
Income	R$53.500/year
Balance	R$45.500/year

CONDOMINIUM OPERATION

PERFORMANCE INDICATOR
Parameters for continued valuation of process

RECYCLING
1-Collected quant./domicile
2-Cost/ton. collected
3-Income by sale/ton.
4-Periodic valuation of recyclable profile

WATER RE-USE
5-Treated water volume for re-use/domicile
6-Treatment cost/m3
7-Excess volume of water
8-Sales income

SOLAR WATER HEATING
9-Heat water volume consumed /domicile
10-Energy economy

SOCIAL AND ECONOMIC ACCOUNTING
Resource generation for amortization of 45% of operational cost of condominium

pay back by unity

Economic Social valuation

9 direct posts of work

Implantation	R$630.000
Investment	R$845/hab
Oper. cost	R$50.500/year
Income	R$184.900/year
Balance	R$133.500/year

BENEFITS ANALYZE

ENVIRONMENTAL CONTABILITY
Reduction of 191.000 Kg/year of waste for embankments
Reduction of 18.000 m3/year of water supply
Reduction 114.000 KWh/year of electric energy
Generation of 64ton/year of organic compound

COMUNITY INCENTIVE
Continuous education by scrap workshops, gardening, horticulture.
Product sale and external publicizing of program evolution.

SOCIAL ACCOUNTING
Social inclusion by generation of 9 direct posts of work and 18 indirects.
Respect and citizenship - revision of relationship man/city.
Ransom of human perception in the context of nature.
Positive impact to adjacent comunity and municipality.

MANAGEMENT
Implantation of undertaking R$5.800.000 (general); R$ 31.000/unity
Implantation by unity R$3.400 (sustainable proposes)
Cost percentage of implantation of sustainable proposes respecting to undertaking = 11%
Pay-back period of implantation of sustainable proposes = 57 months (4,7 years)

Figure 7 – Benefits of sustainable operation – waste recycling, water reuse and solar water heating

Figure 8 – Systemic approach to a sustainable solution for urban centers

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The sustainability of the civil construction perspective

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Abstract
This article focuses the need to search for rationalization of production processes, use and maintenance of buildings in the civil construction area in order to reach sustainability, thus interacting with the environment in a balanced way. Here, the concept of sustainability applied to the civil construction is discussed and an evaluation methodology of building performance is proposed regarding this characteristic. Therefore, sustainability is presented and evaluated by dividing it in relation to the costs of the life cycle, building location characteristics, convertibility and flexibility conditions, internal living conditions, environmental capacities in operations and environmental capacities gathered in the construction elements, safety characteristics, comfort and impact of the building in the neighborhood. The article presents the sustainability indicators and suggests the collecting manner of each one so as to characterize the existing offer as for the sustainable performance. Thus, the result is a checklist guided to the application in the dwelling stock, building sub-area. Depending on the indicator, this can be answered by the dweller, researcher and/or measured with appropriate tools. A study of data collection is conducted in the dwelling stock in the town of Ijuí, in the buildings near the university campus, built in the latest 3 years and aimed at the student market.

Keywords
Dwelling market, sustainability, performance indicators

INTRODUCTION

This article discusses the sustainability theme and its implications for the dwelling market. The study is conducted in the city of Ijuí, which hosts the UNIJUI University (Universidade Regional do Noroeste do Estado do Rio Grande do Sul). The purpose of this work is to define the characteristics and the dynamics of the dwelling market of Ijuí, RS, taking into account the building sustainability.

According to Mülfarth, sustainable architecture "is a way to promote the search for social equality, valorization of the cultural aspects, greater economical efficiency and smaller environmental impact in the adopted solutions in the project phase, construction, utilization, reutilization and recycling of

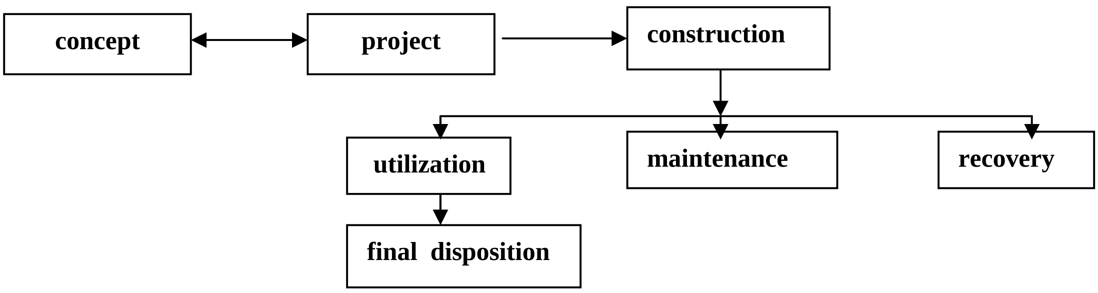
the building, aiming at the equal distribution of the raw material and guaranteeing the competition of men and the cities" [Mülfarth, 2005].
From the eighties onwards, the term sustainability starts to appear with a lot of frequency, becoming an important theme in the social debate. One of the greatest discussions around sustainability concerns the construction of indicators – instruments which allow the measuring of modifications in the characteristics of a system and allow the evaluation of the sustainability of the different systems.

The many discussion fronts about the subject concentrate in the economical, social and environmental aspects. Despite the recent variety of publications about the indicators, few are the efforts to make this concept operative. Hence, this research proposes a strategy for the construction of indicators which allow evaluating the sustainability of buildings.

Another important factor for the research was the awareness that the presence of the university in the urban context stimulates new enterprising initiatives in the dwelling market and, consequently, the socio-economical growth of the city. With the proposed indicators it was possible to evaluate the sustainability of the new constructions which are being incorporated in the dwelling market, as well as the existing ones in the dwelling stock.

The proposed analysis aims at contemplating all the life cycle of the construction according to figure 1. Each phase of this life cycle must be unfolded in its specificities for the analysis to be the broadest as possible.

Fig. 1. Life cycle analysis of the building



The article initially presents the theoretical framework constructed upon the sustainability development perspective founded in the civil construction potentialities and functions. Afterwards, the methodology is presented for the elaboration and application of the indicators and indicators attributes suggested by the building evaluation. Finally, the final considerations of the research are presented emphasizing the importance of sustainability in the constructed environment, the measurement and evaluation of sustainability.

THEORETICAL FRAMEWORK

The sustainability of the constructed environment

The dwelling market is constantly being adjusted in response to the changes not only in the economical conditions of society as a whole, but also in the individual social and economical situations. In this scenery, the expansion and the new constructions perform an important role in the adjustment of the dwellings offer in search of a balance in the market [Gosling et al., 1993].

The dwelling demand, and, as a consequence, the dwelling offer, is a crucial factor for the conformation of the dwelling stock in a city. Considering that the markets identify themselves by the interaction between offer and demand, it is important to verify how the offer conditions are formed and how the demand for dwelling behaves. The conditioning factors of offer relate to the land, physical structures added to the land and the offerers. Concerning the demand, the same author attributes their main determiners to demographic growth, residence prices, family income and credit availability [Balarine,1996].

The construction industry maintains a dynamic relation with economy, being in terms of the level of activities, where the economical development allies to the urban growth and restructuring of the cities, or being in terms of the kind of offer and demand, defined by the particularities of the local economical functions [Brandli and Heineck, 2004]. Moreover, the construction macrocomplex is one of the greatest responsible factors for the environmental impact.

The environmental issues have become more and more important in the sustainable development context. This idea began to spread in the extent of the growth awareness about the natural resources run out. As it can be seen in the BULLETIN CIEF, currently several researchers are endeavoring to identify, and consequently reduce, the impacts related to the civil construction industry, demonstrating the importance of the theme [http://www.cief.org.uk/bulletins.htm]. Some authors already present methods for the environmental analysis of the whole life cycle of the buildings, characterized mainly by the project phases, construction, maintenance and later demolition, since it presents relevant implications in the natural resources consumption and residue generation, lastly in impacts on the environment [Sperb, 2000].

Evaluation procedures of the environmental impacts were used associated to industrialized processes or products so as to evaluate the environmental impacts related to the buildings as a whole; having as purpose the analysis of the life cycle, thus managing to portray in the most complete way as possible, the interactions between the considered process and the environment. This contributes to the understanding of the global context despite the consequences of human activities on the environment, and, still, produces objective information which allows identifying opportunities for environmental improvements [Silva, 2000].

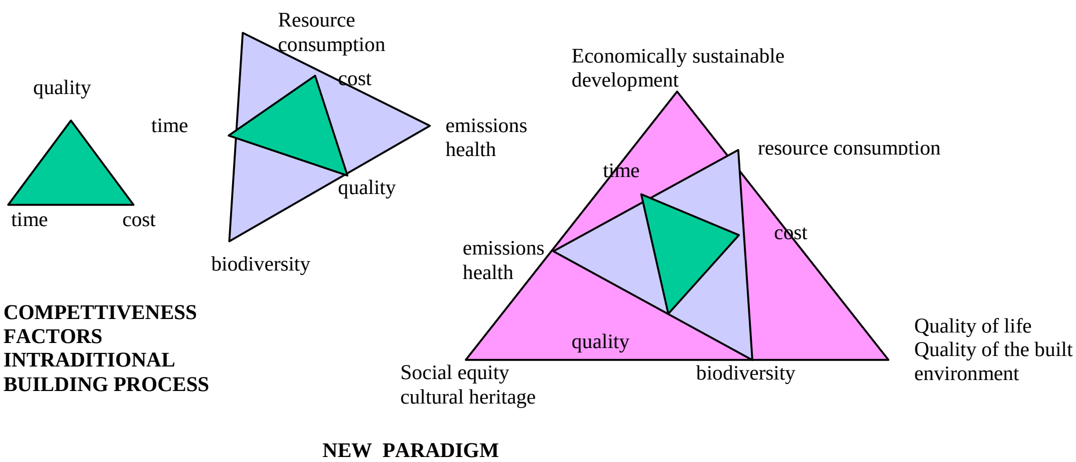
The significant economical participation and growing perception of the massiveness of the environmental impacts provoked by the civil construction industry activities have placed it as a strategic sector for intervention worldwide. In a general way, there are not Brazilian data yet; the water volume, energy and raw material used by the civil construction correspond to at least one third of the total amount consumed annually by the whole society.

The sustainable development was defined by the World Commission on Environment and Development in 1987 as a “development which finds resources in the present without jeopardizing the ability for future generations to find their own resources”. Sustainable construction was defined in the First International Conference on Sustainable Construction in 1994 with the “responsible creation and maintenance of a healthy environment based on ecological principles and efficient use of resources” [Huovila and Koskela, 1998].

In terms of the current environmental advances related to the civil construction sector, it is observed that there are already some analysis methods of the environmental impacts related to a building, being that the majority of them are based on the analysis concept of the life cycle. The life cycle is characterized basically by the phases, since the conception of the product, passing by the project, construction, use, maintenance, recovery and reaching its final disposition. In this context, all the life phases of a product may generate environmental impacts and must be analyzed.

In the article [Huovila and Koskela, 1998] a world panorama of initiatives is presented focused on the edification sustainability and the evolution of the traditional process of construction, the new paradigm focusing the sustainability and its insertion in the global context, as Fig. 2 shows. According to Huovila the concept of sustainable construction is not clearly defined. While traditional design and construction focuses on cost, quality and time, environmental objectives add to these criteria minimization of resource depletion, reducing harmful emissions and maintaining a healthy environment together with conserving natural areas and biodiversity. That can be seen as a new paradigm to construction. In addition, economic, social and cultural dimensions of sustainability become very present especially in the global context. The consumers are already conscious and concerned about their surrounding environment and the sustainability issues are today present. The environment, resource productivity, innovation and competitiveness are linked by an underlying logic and ecological issues belong to the critical success factors. [Huovila, 2005]

Fig. 2. Changes in the sustainable constructions in the global context



Source: [Huovila and Koskela, 1998, p3.]

Performance indicators

It is understood that indicators are a mark or a signal that aim to express some aspects of the reality in order to observe or measure. The measurement provides to the engineers and architects the necessary information to the decision making process and to develop actions to improve the sustainable performance of the constructed environment. Defining sustainability indicators is indispensable so as to evaluate the current performance of the dwelling stock and to subsidize the decisions about the new buildings to be incorporated in this stock. Considering the specific situation to which it is applied, the indicator must conform to the following requirements [www.cpgec.ufrgs.br/norie/indicadores].

Selectivity: the indicators must be related to essential or critical factors of the product (building) to be evaluated, identified from a strategic perspective. **Representation:** the indicator must be chosen or formulated in a way that may represent satisfactorily the process or product to which it refers to.

Simplicity: they must be of easy comprehension and applicability mainly for those people directly involved with the collection, processing and evaluation of the data. **Low cost:** they must be generated in a low cost. The cost for the collection, processing and evaluation must not be superior to the benefit brought by the measurement. **Accessibility (transparency):** the data for the calculus of the indicator must be of easy access and be available preferably through visual mechanisms. **Stability:** they must be collected based on routine procedures incorporated to the activities of the enterprise and allow their comparison or trend analysis throughout time. **Experimental approach:** it is recommended to develop initially the indicators which are considered necessary and to test them. **External comparison:** some indicators must be developed in order to allow the comparison of the building performance to enable them to be used as benchmarks. **Continuous improvement:** the indicators must be periodically evaluated, and when necessary, must be modified or adjusted to conform to the changes in the environment and no to lose their purpose and validity.

METHODOLOGY FOR THE ELABORATION AND APPLICATION OF THE INDICATORS

The methodology for the construction of the indicators comprehended the following phases:

1) **Identification of the target public involved:** defining the people who will be involved in the collection of the indicators, who may be the technician (researcher) or the user of the building to be evaluated depending on the indicator. In this item, the system is also geographically limited (place, region, city, community), the time scale is determined (periods of analysis during the life cycle) and the system to be evaluated is characterized, including a clear description of the following aspects: kind of building (house, building or industry), function (residential, commercial or industrial).

2) **Determination and characterization of the study object:** defining the building to be studied, according to the specific objectives of the research. The characterization of the buildings is carried out through photographical registers for a better visualization of the studied situations; application of a questionnaire with the dwellers to obtain information about their satisfaction concerning the environmental performance of the building; analysis of the architectural project and of the describing memorials of the buildings, enabling the characterization of the apartments concerning the solar orientation, specification of the building materials, openings, lightening, etc. and *in loco* visits to collect climatic data, specification of the building materials, area checking, collection of necessary data, as well as checking whether the building was executed according to the architectural project.

3) **Definition of the sustainable development**: conceptually defining the sustainability pattern that is desired for the buildings to be studied. In this item it is important that the sustainability be oriented for the local reality, incorporate technical, economical, social and environmental aspects.

4) **Determination of the attributes or characteristics of sustainability**: defining which attributes will be evaluated and which characteristics for each attribute to be considered sustainable. The attributes related to law, construction materials used, building location, quality in the use, operation and maintenance, environmental comfort and cost throughout the life cycle were considered.

5) **Indicators rising:** elaborating a list with a broad set of technical, economical, social and environmental indicators which characterize each attribute based on its comprehension of sustainability and other definitions of the previous steps.

6) **Selection of strategic indicators**: from the set of indicators raised, the strategic ones must be selected; those which will be measured, monitored and evaluated.

7) **Identification of a weight for each indicator:** the weights were attributed in an equal way to all the indicators which compose the attribute. The main objective of the identification of a weight for each attribute is to be able to ponder about the results of different buildings analyzed for the comparison among them. The qualitative analysis of each indicator is carried out simultaneously and shows the main deficiencies of each building in relation to sustainability.

8) **Determination of parameters:** the determination of parameters is important so as to evaluate the obtained indicator. For that it is necessary a bibliographic and data already collected search of buildings which are benchmarking for each indicator.

ATTRIBUTES AND INDICATORS FOR THE EVALUATION OF THE BUILDINGS

Among the variables that translate the sustainability in the civil construction, the suggested ones in this study are enumerated in Table 1. The attributes which can be analyzed in each building as well as the indicators connected to each one of them are presented in this table; the measurement form, the source of each indicator – data collection; the kind of evaluation of each indicator – if exclusively technical, or if it will be evaluated by the dwellers and finally the weight attributed to each indicator. It is understood that for a better comprehension of the matter the attributes and indicators may and must be analyzed together and isolatedly.

The studies carried out until the moment allowed the understanding that the auto-sustainability of the buildings may be achieved through the flexibility of the project, building techniques, materials used in the conception of the building, recycling of rain and drain water, use of solar or wind energy, garbage recycling, reduction of consumption of water and the use and occupancy of the soil. Aspects such as solar incidence, dominating winds, surrounding characteristics and use given to the building must be considered before defining the positioning on the lot, walls width, opening dimensions and the materials to be employed. The choice of the materials in the sustainable construction should, in principle, obey to environmental preservation, recovery and responsibility criteria. This means that, when a construction is started, it is important to consider the kind of materials that may contribute to preserve and improve the environment where it is inserted.

Currently, there are several products and materials developed in a way to preserve natural resources. It is understood that the legislation interferes directly and in different ways in the sustainability of the buildings, for instance, when it allows the division of the soil in very small lots it implies smaller retreats, bigger impermeabilized areas, high constructed density or buildings which barricade the passage of the wind, among many other situations. The issue of occupancy of the soil in a lot is of extreme importance, since it determines in an ultimate analysis the environmental quality of an urban sector. The urban rates aim at guaranteeing the control over the demographic and construction densities, which, in its turn, preserve the ideal conditions of acoustic, thermal, lightening and other comforts if adequate. It is observed that in Brazil there is not a regulation in the performance that a certain building must have, there are, however, principles and parameters in the sustainable architecture that may be found in the ISO 14000 rules or in the Agenda Habitat, documents that provide directions for the sustainable development. Among the novelties are the new goals established by the federal government from the Programa Brasileiro da Qualidade e Produtividade do Habitat (PBQP-H).

It is worth to also highlight that the building is understood not as an isolated element, but it is related to other elements in the block and this, on its turn, to a bigger system that is the city. Thus, endeavoring to solve the problems of the building contributed to the balance of a bigger system, making it possible for them to be worked in an integrated way providing 'ideal performance'.

Table 1. Attributes and Indicators for the Evaluation of the Buildings

ATTRIBUTE	INDICATOR	FORM OF MEASUREMENT	VALUE	DATA COLLECTION	EVALUATION	WEIGTH
Legislation	Occupaçcy tax Good use index Permeability tax Front retreat Left distance Right distance	Quantitative Qualitative	10	Architectural Project	Techcnical	
			Σ/6			1
Construction Materials	Walls; Floor Int. and external finish Frames ; Covery	Qualitative	10	Memorials "In loco" inquiry	Technical	
			Σ/6			2
Location	Surrounding characteristics Traffic conditions Communications Effects in the neighborhood	Qualitative	10	"In loco" inquiry Interview Questionnaire	Technical Users	
			Σ/4			1
Project Quality	Circulation index Índice de compacidade Garage circ. index Wall density Flexibility of usage Functionality	Quantitative Qualitative	10	Architectural Project "In loco" inquiry Interview Questionnaire	Technical Users	
			Σ/5			1
Use/maintenance quality	Energy ; Water Liquid debris Solid debris Repair facility Durability; Safety	Quantitative Qualitative	10	Accounts Extracts "In loco" inquiry Interview Questionnaire	Technical Users	
			Σ/7			2
Environmental comfort	Natural lightening Artificial lightening Acoustics Hydrothermal Comfort Ventilation	Quantitative Qualitative	10	"In loco" inquiry Interview Questionnaire	Technical Users	
			Σ/5			1
Cost	Inherent costs to each phase of the life cycle: Project; Construction; Utilization	Quantitative	10	Market data	Technical	

			Σ/3			2
					Σ total	**10**

CONCLUSIONS

This article showed the characterization of the concept of sustainability in civil construction, sub sector buildings, through the elaboration of an indicator proposal. It is expected that the final results of the research point to a 'value' of sustainability, achieved by each building selected as a case study, from the sum of all the indicators, duly pondered through the weights attributed to the indicators. It is highlighted, however, the necessity to reflect about the barriers in the context of civil construction which need to be overcome:

a) Innovation: use of alternative materials aiming at the environmental comfort and new construction techniques; b) Empowerment**:** the majority of the available labor force in the Brazilian market has little formal education, being characterized in general as repeaters of traditional methods. This makes a simple innovating technique difficult to be transmitted, no to mention the resistance in learning; c) **S**ystemic View: management of the involved personnel and constant supervision for the integration of all the parts; d)**Sc**ientific: greater scientific knowledge applied to new technologies is necessary to broaden the concept of sustainability in constructions.

To reach quality of life, with a minor cost, is the great challenge, as the parameters related to sustainability are decisive in the sense of establishing a good performance in the project. This research is a proposal which needs to be improved and multiplied for a greater comprehension about the building impacts in the environment. There is a new market to be explored, a market that can establish new rules, with more responsibility and within the socio-environmental ethics [Capra, 1996]. In order to do so, there is a need for this knowledge to be part of the syllabus in the engineering and architecture courses, as well as in the empowerment courses for the professionals of this area.

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Developing a More Sustainable Urban Residential Area – Genesis Project

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Abstract
The traditional approach for urbanization of a land plot begins with the removal of all vegetation that is legally allowed to be removed; planted new trees usually replace a small fraction of the removed vegetation. The assumption is that larger area available for sale, higher financial return; consequently, preservation - or green areas - are deemed to be less interesting profitwise.
Such paradigm destroys the local biota, thus resulting in a built environment where the population has little contact with nature, heat islands increase thermal discomfort outdoors and energy demand for air-conditioning, water becomes scarce, and storm waters periodically flood some areas of the city.
This paper presents guidelines on developing a more sustainable urbanization practice, based on a case study of a 3.6 million square meter private development. Among other measures, plots take only 15.9% of the total area, and the total Atlantic forest green area was increased by 24.8%, reaching 73.4% of the total area. At the same time, adequate financial return to investors was obtained.

Keywords
Sustainable development, urban residential, plotting, civil engineering, genesis.

Introduction

This paper presents guidelines for a more sustainable urbanization practice, based on the experience of the urban development called "Genesis Project", by Y. Takaoka. It contains data and comments on the environmental and social benefits from the adoption of a sustainability-based paradigm, in conceiving, planning, building and deploying urban areas for residential use, in comparison with the results from other real estate developments located in the same region and focused on the same market. The project combines the social concept of housing with the concept of environmental preservation, and concomitantly, satisfies man's yearning for good dwelling, with positive economical results for ventures and suppliers, and last but not least, generates new jobs and more income for the region.

To illustrate this practice the cases Genesis I and Genesis II are shown, which consider the several stages of an urban development that totals over 360ha, with 270ha destined to environmental preservation areas and only 16% for residential plots.

Characterization of the market practices

The table below shows the exclusively residential plot developments located in the region of Alphaville, in the municipalities of Barueri and Santana do Parnaiba, west of Sao Paulo city, in Brazil, launched at a time when Law 6.766[1] was in force. The following percentage figures are noteworthy: plotting area in relation to the total area: near 60%; green area/total area: 15% in average; green area per plot: an average of 120 m2/plot or 30m2/inhabitant (considering 4 inhabitants/plot, in the region of Alphaville, according to figures from IBGE – the Brazilian Institute for Geography and Statistics).

Table 1 – Plotting Developments Implemented in the Region of Alphaville above Law 6.766

Apr – 79 Aug – 90	Total Area (m^2)	Plotting Area (m^2)	Green & Leisure (m^2)	Total Plots	Average area of the plots (m^2)	Plotting Area/ Total (%)	Green Area /Plot (m^2)	Green Area/ Total (%)
Totals	5,317,058	3,226,239	814,558	6,694	482	60.7%	121.68	15.3%

Source: RP Architecture

Introducing sustainability in real estate developments

According to CHAFFIN apud WILSON (1998, p. vii/ix), there is a need to seek for urban development solutions that result both in better communities for the population and [not only] in less waste of the natural resources, but also in a better accommodation of the natural systems. "Emerging psychographic, sociographic, and cultural trends indicate that the market is most receptive to products that are the result of responsible ecological stewardship." "There is a preoccupation with quality of life, with an emphasis on health over wealth, and a focus on well-being as opposed to being well-off." ... "... people have a natural predisposition to feel better, perform better, and actually exhibit healthier physiological signs when looking at water, green vegetables, or flowers, versus 'built' structures of glass and concrete. It is ironic that we often use our human creativity to destroy that which we truly need to live healthy, satisfied lives. If the natural landscape is indeed such a tonic, then we as developers must be sensitive to a greater sense of community – the web of life that links nature and humanity."

As more people and businesses place greater strain on living systems, limits to prosperity are coming to be determined by natural capital rather than industrial prowess - HAWKEN et al (2000, p. 2). On the other hand, NASH (1994), in his work on the Game Theory for which he was awarded the 1994 Nobel Prize in Economics, concluded that the equilibrium points in decisions involving individual and collective interests of the group are reached when all the participants maximize not only their own pay-offs but the group's as well.

The concept

According to HAWKEN et al (2000, p. 87), green projects typically sell or lease faster**,** because they combine superior amenity and comfort with lower operating costs and more competitive terms…

[1] Law 6.766 of 1979 provided for the parceling out of the urban land, and was amended by Law 9.785, in 1999. Initially, a minimum of 35% of the total area had to be public (green areas, as well as areas for leisure systems, road systems and institutional use), thereby leaving a maximum of 65% for the residential plotting.

“These improvements in turn create a key competitive advantage, and hence further improve real estate value and market performance.”

Opposite to the premise of maximizing the commercial areas (residential plots) to maximize economic results, green real estate developments are guided by the principle of making natural resources (the amount of green area per inhabitant and the amount of water available in the region to meet the needs of urban development) compatible, to comply with the social demand for habitat, thereby aggregating value to the real estate business by increasing the environmental quality of the project.

Environmental aspects: A key link for the project’s sustainability

The main problems found in urbanized areas concerning environmental impacts, especially large metropolitan regions such as Sao Paulo and its suburbs, are as follows: (i) removal of vegetation, with total loss of regional typical flora and, consequently, related fauna; (ii) reduction in the soil permeability by the increased surface flow of rainwater that causes flooding in lower areas during heavier rainfall, and reduction in groundwater recharge; (iii) production of “heat islands” from solar energy, with a rise in air temperature causing the population heat discomfort and increasing the demand for energy due to the necessary use of air conditioning systems; (iv) contamination of surface and underground water resources by pollution, especially urban sewage and, in many cases, industrial effluents; (v) contamination of water resources by floodwaters that drag different kinds of waste from the course; (vi) shortage of surface and underground water due to removal of more natural water resources than is required to recharge existing aquifers; (vii) air pollution caused by air and land transportation systems, as well as industrial plants; (viii) visual pollution from urbanization, not always related to landscaped areas, and proliferation of slums; (ix) noise pollution from heavy traffic and car horns, and the constant hum of densely inhabited areas.

Social Aspects

The main social aspects that need to be contemplated are: (i) complying with the housing needs of man; (ii) conducting consultancy and research activities together with universities and NGO’s, aiming at perfection and replication of the project; (iii) divulging accumulated knowledge through academic, technical and entrepreneurial media, with a view to disseminating the project and its replication; (iv) upgrading the environmental and social conditions; (v) promoting environmental education among the community to make the pro-environmental and pro-social actions implemented by the developers into everlasting achievements; (vi) generating more jobs, and finally, (vii) bringing wealth to the region.

Table 2 – Human being structure and his perception of value

Base	Body	Mind	Spirit
Objective	necessity	desire	dreams
Influence	location	culture	faith
Sensation	comfort	well being	felicity
Characteristic	commodity	niche	essence
Value	competitive	aggregate	priceless

Based on the knowledge of qualitative and quantitative attributes of the area and of the necessities, longings and aspirations of the target-population, we can perceive environmental opportunities of the area and the local social characteristics, both of which can be positively aggregated into the project.

The successful implementation of an urban residential area implies knowing the necessities, desires and dreams of the target-population. Green urban developments attend to two major aspects of the issue: they satisfy man’s yearning for a good home and they join value to the product through the uniqueness of its characteristics.

The economical and financial indicators

Compliance with the third fundamental aspect of sustainability demands that cost and income be balanced to support this kind of project. Judicious analysis must be made to balance cost vs. environmental and social gains at the same time that consideration towards a target-population can never be disregarded. What are their aspirations? How much can they afford to pay? How do they appreciate the value of the product being sold?

Furthermore, economic outcomes must be compatible with market parameters for remuneration of labor and invested capital. Further still, financial resources must be sufficient to support the project’s investment needs as well as for its implementation. There must be economical sustainability for the entrepreneur implementing the venture and for the dweller: the latter shall upkeep the common urban spaces and the natural riches of the place.

Case study: The project Genesis I and II

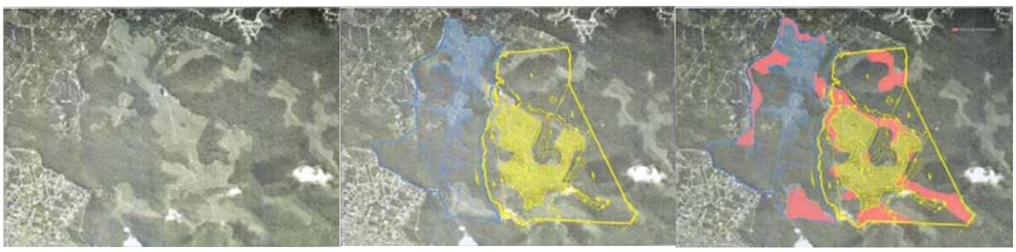
The urban residential plotting developments called Genesis I and Genesis II are located in the Municipality of Santana de Parnaiba, in the State of Sao Paulo, Brazil. Genesis II is in the urban structure implementation stage (earth works, accesses, rainwater drainage system, sewage system....) and Genesis I, with its infrastructure completely finished, was delivered to the owners in March 2004. More than forty houses are being built and six families have moved until October 2005.

Besides the urban infrastructure works, a program is being established for the recovery and preservation of the environment, coordinated by Brazilian Foundation for Sustainable Development (FBDS), which encompasses a reforestation program to expand the original woodland by more than 50ha, and specific programs for the enrichment of the biodiversity – fauna and flora.

Area distribution

Over 70% of the total area is destined for environmental preservation, whereas 16% is for plotting. Also noteworthy is the fact that in Genesis I and II the forest area will be enlarged by 24.8% vis-à-vis the original green area, that is, the fauna and flora biodiversity conditions of the region shall be improved.

Figure 1 - aerial picture (1994) before the works, with the plots and with the reforestation area



Almost 50% of the total area was voluntarily donated to a not-for-profit organization composed by the future residents of the Genesis I and II residential condominiums. The social objectives of the association are: the protection, defense, preservation and restoration of the environment and of the regional biodiversity, and the resulting upgrading in the community's quality of life.

Table 3 – Data and Indicators of Genesis I e II Developments

		Genesis I	Genesis II	Sub-Total	Residential 10
Residential plots		466	598	1,064	
Green and Leisure areas	(m^2)	1,120,909	1,438,419	2,559,328	196,631
Green and Leisure areas/plot	(m^2)	2,405	2,405	2,405	
Residential plotting area	(m^2)	223,798	331,083	554,881	-
Green area expansion	(m^2)	186,035	330,515	516,549	-
Total project area, donations included	(m^2)	1,527,603	1,960,315	3,487,917	196,631
Original green area (Sept/89)	(m^2)	817,397	1,264,667	2,082,062	196,631
Green expansion/original green area		22.8%	26.1%	24.8%	
Green expansion/total area		12.2%	16.9%	14.8%	
Plotting area/total		14.7%	16.9%	15.9%	
Green & Leisure areas/total		73.4%	73.4%	73.4%	

Market Surveys

According to KOTLER (1999, p. 47), a survey is the starting point for marketing. Without it, a company goes blindly into the market. Good marketing involves careful research of the market opportunity and the preparation of financial estimates based on the proposed strategy, which will signal if the returns would meet the financial objectives of the company.

Table 4 – Some of problems and opportunities

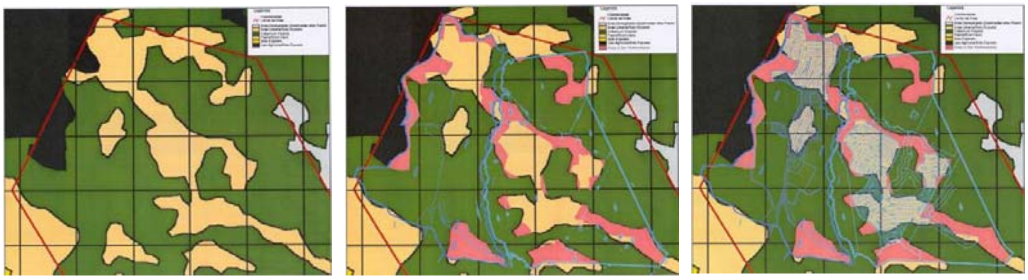
Perceived Problem	**Consequence**	**Foreseen opportunity**
Large expanses of woodland	Environmental Costwise	Meets the customers' longings.
Only 18% of the area made into plots for sale	Earnings reduction	Large stretches of green in the neighboring area fulfill the longings of the customers, who eventually help with the preservation.
Difficult access	Cost and Technical Problems	Privacy and the possibility of reaching home through a tunnel of green.
No water from the waterworks company ("SABESP")	Unfeasibility	Semi-artesian wells and local water springs; building a water dam.
Necessity of building up a dam to capture water	Cost	Beauty, value aggregation and help in controlling floodings downstream of the enterprise.
Sewage treatment above the required level	Cost	Acknowledgement by community; pro-environmental preservation
Ecosustainability of the Project	Cost	Aggregated value and environmental preservation.
Project to meet the longings of the community and of the customers	Cost	Aggregated value resulting in a great sales success at a price compatible with costs and risks.

There is no way a company can be active in the market without knowing the necessities, desires and aspirations of the target-population, its financial capacity and the demographic growth, through market surveys conducted by well-qualified professionals. In the present case, the survey conducted in 1998 by Datafolha and Wilma Rocca indicated that 84% of the inhabitants of the region consider it important to have forest reserves, and about 70% of them considered important the existence of leisure and sport facilities, while other surveys point to the financial capacity, price perception of the product, problems and opportunities.

Environmental aspects

When planning the Genesis Project, comprehensive analyses were carried out to prevent negative environmental impacts cited above and to restore natural environment characteristics of the original Atlantic rainforest in the region.

Figure 2 – Analysis of Genesis I and II over interpretation of Terradatum image from Landsat 5



In the Figure 2, the first image is from Landsat 5 (Sept/12/88)[2] as interpreted by Terradatum, by request of FBDS, where the green areas represent the woodland, the creamy ones are pastureland and those for agricultural use are black. The second one shows the areas for reforestation in pink, and the third shows the implementation of Genesis I and II.

The lands chosen were predominantly botanic pastureland (areas deforested long ago) to implement urbanized areas including allotments and road systems, see **¡Error! No se encuentra el origen de la referencia.** totaling only 27% of the project area; the other 73% covers green areas with tree vegetation. Another attention-deserving aspect that was cared for, is the priority given to the formation of extensive natural forest areas instead of the many isolated fragments of green which have resulted from the governmental guidelines in several environmentally-protected areas. The biodiversity of fauna is the major beneficiary, since preserved expanses of land are of the foremost importance for their living, feeding and procreating conditions.

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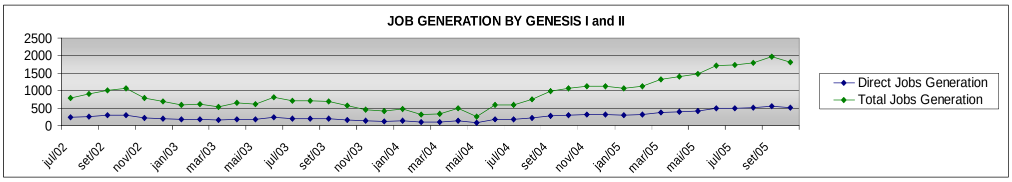
The water resources are managed in order to meet the estimated water demand of 1,328 m3 per day. Of this total, 426 m3 come from underground aquifers and 902 m3 from a reservoir that is recharged by the spring runoff. These flows do not hinder the average stocks of water available in the drainage sub-basin where the project is planned. To maximize the use of water resources, the plan is also to reuse effluent water from the sewage treatment plant. To achieve this and prevent contamination of the water resources, a sewage treatment plant is planned with advanced technology and treatment to the tertiary level. After chlorination, the effluent water may be recycled to be used in various activities, especially irrigation of the grassy areas and in the forested areas to prevent fire hazards that might occur in years with long dry periods.

[2] By the Kyoto Protocol, the image must be previous to 1989.

Social aspects

According to MUNRO & HOLDGATE (1991, p. 11), “properly mandated, empowered and informed, communities can contribute to decisions that affect them and play an indispensable part in creating a securely-based sustainable society.”

Together, up to October 2005 Genesis I and II generated 515 direct jobs that resulted in 1,800 jobs according to the job generation model where each direct job generates other 2,5 (BNDES/CN99, MIP96, PNAD99, POF95/96), as shown in the graphic below.



(Source of direct jobs: Y. Takaoka and Genesis I Communities Association)

Having green areas, eg. in squares, parks, or woods around the urban site is very important to assist with the psychological cultural and health needs of man. The World Health Organization (WHO) recommends a minimum of 12 m2 green area per inhabitant. Today the city of Sao Paulo offers around 4 m2/inhab and the city of Curitiba, State of Parana, considered an environmental quality benchmark, offers 40 m2/inhab. The Genesis I project lavishes around 600 m2/inhab of green area, considering an average occupation of four inhabitants per plot of land.

Besides meeting the housing needs of man, residential projects Genesis I and II demanded extensive research, exchange of knowledge and integration of various specialized groups (engineers, environmentalists, administrators, lawyers and several market and survey consultants), generating a substantial amount of jobs, as shown above, that resulted in an innovative, paradigm-setting product in the Brazilian real estate market.

Economical Aspects

For the sustainability of the Genesis Project, it is mandatory that investors be offered profit margins at a par with those yielded by similar investments in the real estate business. From the pre-launching period through the delivery of Genesis I, the inflation rate was 40%, the “CDI”s (certificates of inter-bank deposit – reference parameter for interest rates in the Brazilian economy) yielded 48%, and the plot prices were raised by 80%, according to sales.

Also, the investment quality indicators on the Genesis I Project, as per below, constitute an attractive factor for those realtor developers interested in this kind of enterprise. The quality indicators of the Genesis I enterprise are as follows: [i] 25.2%p.a. internal domestic return rate; [ii] 25.8% result on the sales volume; [iii] 41-month primary payback; [iv] 12 million investment in “Reais”, or 13.8% VGV, which is considered low because the land was bought by the developer.

Conclusions

Table 5 – Comparative data: Other developments vs. Genesis I e II

Development	Plotting area/Total (%)	Green area per plot (m^2)	Green area/Total (%)
Others (average)	60.7%	122	15.3%
Genesis I	14.7%	2,405	73.4%
Genesis II	16.9%	2,405	73.4%
Genesis I and II (average)	15.9%		

Looking at the table above one can easily make a comparative analysis of the average indicators of Table 1 and 2. It clearly shows the inversion in the use of green areas versus those destined for plotting in the other developments of the region, vis-a-vis the figures for the allotment practiced in Genesis I and II. It can be noticed that the amount of green areas in Genesis Projects are almost five-fold superior in percentage figures and almost 20-fold larger in absolute numbers regarding the per plot green area.

Genesis Project, its concepts and principles, proceeds towards a more sustainable urban development, according to the longings of man, contributing to the improvement of environmental conditions, generating more jobs and wealth in the region in an economically attractive mode. For that, a multidisciplinary knowledge is required, involving several kinds of professionals and organizations.

Genesis Project is meant to be a dynamic one. One that learns from its own mistakes and progresses along with time, from technological breakthroughs, from the ever-present hampering setbacks which come up together with new opportunities – one in seek of higher quality of life for the community and of perpetuating the ecosystem for the generations to come. It takes great creativity and emotion to make a project like this come true. Technical expertise only is not enough: it calls for real knowledge of the feelings, sensations and anxieties of the human being, to try to adjust and incorporate all these elements, in a sustainable manner, into the project.

We need to set the eyes beyond the present, to the future of the human race and to the future of the planet. We need a holistic understanding of the social, environmental and economic demands to achieve a higher quality of life for the present and the future communities, and, at the same time, we need to warrant the life of the company by balancing the costs with the value added by the quality of the project. Mainly in developing countries, where there are so many things to do for the people and for the environment.

“Rethinking design is not only a matter of improving hardware but of looking at the context in which we live and work every day” … “for example, clustering houses around mini-greens preserves privacy but offers shared pocket parks and gardens and fosters neighborliness.” … “The unexpected and outstanding success of such integrated-design projects in real estate markets is starting to persuade developers to rethink many of their basic assumptions and reimagine development as a tool for restoring nature and communities.” HAWKEN et al (2000, p. 106-109)

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Towards an International Construction Management System: The Semisphere Model

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Abstract
This research seeks to identify and implement a cohesive approach to global construction management by analyzing regional key growth indicators juxtaposed against an historical summation of political conditions. The sum result of this research will be a model against which to measure regional statistics as a means of discerning opportunities for physical growth and expansion.

By compiling a random group of data sets from regional statistics ranging from broad indicators such as GDP to more specific indicators such as new satellite television subscriptions, one is able to discern an implicit correlation with the political climate in a particular nation.

Applying the findings of the research to the subject of analyzing global conditions favorable for construction growth, the Semisphere Model was derived. This model divides these data sets into four distinct "semispheres" subject to the strength and stability of a "political axis". These "semispheres" are identified as Economic Environment, Feasibility Issues, Cultural Concerns, and Societal Benefit.

This model will streamline the effort of analyzing a region's growth potential as well as compile a data set that can be further utilized in the development of project budgets, timelines, resource usage, and other more detailed components of construction management.

Keywords
Semisphere, construction management, political axis.

ESTABLISHING RESEARCH PARAMETERS

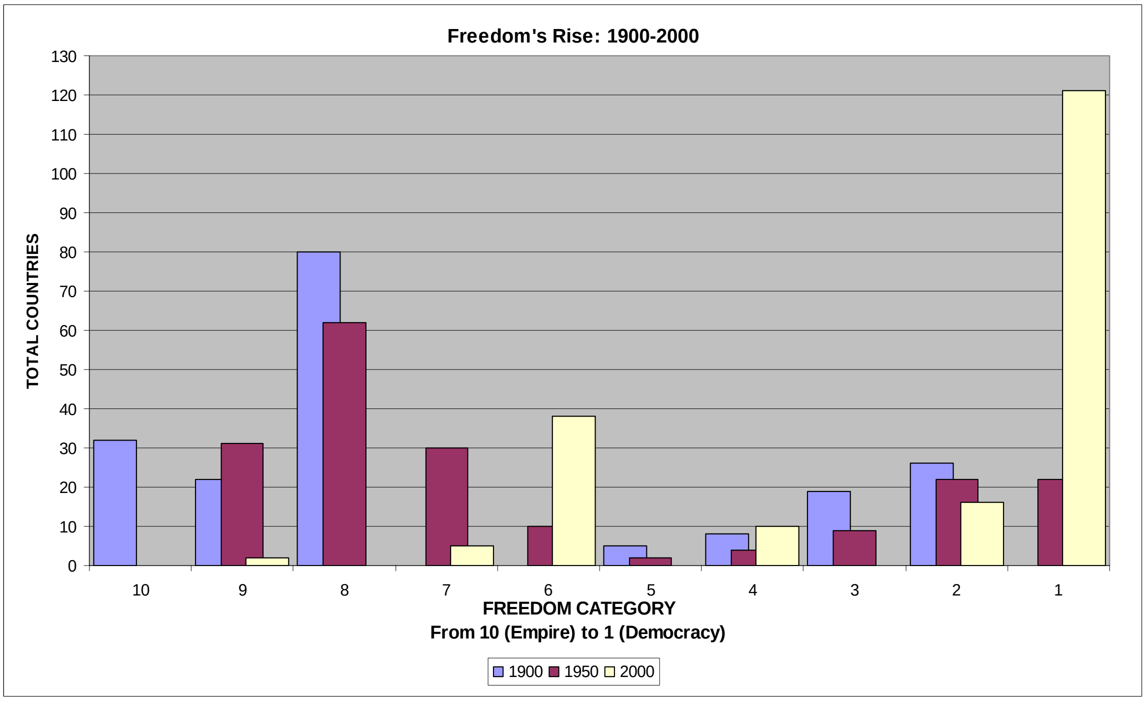
Creating a singular, unified system with which to approach global construction management has historically proven to be a daunting and cumbersome undertaking. Without a means of channeling investigative findings into an organized collection of facts, the output of such conclusions generally defaults to a purely economic endeavor. Given the tremendous dissimilarities between nations, it is necessary to take a step back, removed from the business aspect of construction. The process detailed herein is the first step towards applying an understanding of construction management planning to the global condition.

The benefit of this process goes beyond providing a simple formula from which to glean the economic potential of an area. Rather it begins to take into account a level of cultural and societal benefit, to begin to address global construction on a local level. In a global economy, it is important to maintain a perspective on the region within which the project is proposed, focused on not only the economic trends but also the cultural influences. While doing so, it is necessary to recognize the underlying political climate. At its very base, the political environment influences the direction of a society, thus providing the basis from which to pursue this research.

The Political Axis

Throughout history, nations have defined themselves by their political underpinnings. The primary dictate of a community's sense of pride and the growth of a people is rooted in the political atmosphere. Over the last hundred years, there has been a discernable advance of democracy in the world. The graph below (Fig. 1) dramatically reflects this surge in freedom.

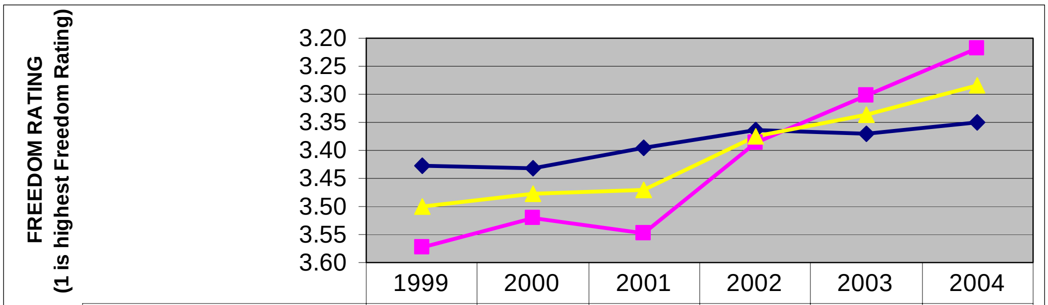
Fig. 1 Summation of political conditions for the last century



"Like economic progress, political progress has been uneven. But the general trends are hard to ignore. They reinforce the conclusion that humankind, in fits and starts, is rejecting oppression and opting for greater openness and freedom." [Freedom House, 1999]

A more detailed examination of recent history (Fig. 2) exhibits a continued trend towards freedom. Of particular interest is the rapid growth of civil liberties representing the introduction of autonomy to countries unfamiliar with such freedoms. Political rights expectedly lag, as old regimes and outdated mentalities are more difficult to supplant.

Fig. 2 Detailed analysis of global freedom conditions in recent history



	1999	2000	2001	2002	2003	2004
Political Rights	3.42708	3.43229	3.39583	3.36458	3.36979	3.34896
Civil Liberties	3.57292	3.52083	3.54688	3.38542	3.30208	3.21875
FREEDOM RATING	3.500	3.477	3.471	3.375	3.336	3.284

With this surge of democracy has followed a great deal of physical transformation in the world. The rise of developing nations presents a new challenge in construction, requiring a swiftness and dexterity to manage a sudden influx of capital resources with an ingrown abundance of human assets. These new conditions present the opportunity to implement a system as a means to rapidly analyze a country and determine its potential. The first step is to gather the historical trend of political conditions in an area. This will be the basis against which all other gathered information will be measured. From this, the economic, infrastructural, societal, and cultural trends will begin to materialize.

Utilizing data compiled by Freedom House, a non-partisan collaborative effort established to chart the growth of democracy, Table 1 reflects the typical first step in analyzing a region's political environment. This table details fluctuations in Political Rights and Civil Liberties in a region by assigning a ranking value between 1 and 10 (1 being the most free). Using this scale, the below noted study case of Argentina exhibits a regression from freedom in 2001-2002. By 2003, however, there is a shift back towards freedom. This information will provide a base for the remainder of the research process.

Table 1. Analysis of political conditions in Argentina

	1999			2000			2001			2002			2003		
	PR	CL	Status	PR	CL	Status	PR	CL	Status	PR	CL	Status	PR	CL	Status
Argentina	2	3	F	1	2	F	3	3	PF	3	3	PF	2	2	F

Source: *Freedom in the World* ratings of events through November 30, 2003

Selecting Research Parameters

A random cross section of regional statistics is now examined to illustrate the parallel of political atmosphere to civic growth. Selecting data of too narrow a focus may provide expected results, however it will not provide the unanticipated knowledge that this process is designed to produce. Through this process, trends will become evident and lend a deeper understanding to the political atmosphere. When applied to the model described later, this information will begin to form a more complete representation of the area under examination. For now, it is important simply to gather the raw data. The set of random statistics below (Table 2) is collected by utilizing the World Bank's World Development Indicators database. This is an example of a cross section of data that could typify this step in the research process.

Table 2. Random collection of regional data from Argentina

Argentina	1998	1999	2000	2001	2002	2003
Agricultural machinery, tractors	298,952	299,172	299,280	299,608	299,620	
Air transport, passengers carried	8,446,500	9,191,900	8,904,200	5,808,800	5,510,100	6,030,100
Cable television subscribers (per 1,000 people)	168	166	165	163		
Electric power consumption (kwh per capita)	1,941	1,995	2,105	2,107	2,024	
Fixed line and mobile phone subscribers (per 1,000 people)	281	332	389	416	396	
GDP per capita (constant LCU)	8,186	7,835	7,704	7,300	6,448	6,962
Immunization, measles (% of children ages 12-23 months)	99	99	56	94	97	97
International tourism, expenditures (current US$) / 1000	5,282,000	5,228,000	5,460,000	4,888,000	2,744,000	3,080,000
Internet users (per 1,000 people)		34	73	101	112	
Manufacturing, value added (% of GDP)	19	18	18	17	22	24
Military expenditure (current LCU) / 1000	3,962,000	4,143,000	3,739,000	3,726,000	3,755,000	4,233,000
Mobile phones (per 1,000 people)		125	169	193	178	
Permanent pasture (% of land area)	52	52	52	52	52	
Personal computers (per 1,000 people)	55	59	71	80	82	
Rail lines (total route-km)		28,291			35,754	
Researchers in R&D (per million people)	722	732	737	709	715	
Roads, paved (% of total roads)	30	29				
School enrollment, secondary (% gross)	89	94	97	100		
School enrollment, tertiary (% gross)	47	48	52	56		
Television sets (per 1,000 people)	305	321	321	326		
Trade (% of GDP)	23	21	22	22	40	39
Source: *World Development Indicators* database						

Interpreting the Data

The analysis in Table 3 adds some quantifiable measures to the raw data presented in Table 2. First, it digests the trend from year to year for each of the parameters. The trends in this instance can be defined as the growth or decline in each data set for each succeeding year then assigned a value ("1" for positive growth and "-1" for a decline). The summation of these values across the field of regional statistics presents a quantifiable leap from raw data to executable information. It is now possible to discern a trend that can be compared against the political trend gathered earlier.

Table 3. Trend analysis of regional data

Argentina	1999		2000		2001		2002		2003	
Agricultural machinery, tractors	+	1	+	1	+	1	+	1		
Air transport, passengers carried	+	1	-	(1)	-	(1)	-	(1)	+	1
Cable television subscribers (per 1,000 people)	-	(1)	-	(1)	-	(1)				
Electric power consumption (kwh per capita)	+	1	+	1	+	1	-	(1)		
Fixed line and mobile phone subscribers (per 1,000 people)	+	1	+	1	+	1	-	(1)		
GDP per capita (constant LCU)	-	(1)	-	(1)	-	(1)	-	(1)	+	1
Immunization, measles (% of children ages 12-23 months)			-	(1)	+	1	+	1		
International tourism, expenditures (current US$)	-	(1)	+	1	-	(1)	-	(1)	+	1
Internet users (per 1,000 people)			+	1	+	1	+	1		
Manufacturing, value added (% of GDP)	-	(1)			-	(1)	+	1	+	1
Military expenditure (current LCU)	+	1	-	(1)	-	(1)	+	1	+	1
Mobile phones (per 1,000 people)			+	1	+	1	-	(1)		
Permanent pasture (% of land area)										
Personal computers (per 1,000 people)	+	1	+	1	+	1	+	1		
Rail lines (total route-km)							+	1		
Researchers in R&D (per million people)	+	1	+	1	-	(1)	+	1		
Roads, paved (% of total roads)	-	(1)								
School enrollment, secondary (% gross)	+	1	+	1	+	1				
School enrollment, tertiary (% gross)	+	1	+	1	+	1				
Television sets (per 1,000 people)	+	1			+	1				
Trade (% of GDP)	-	(1)	+	1			+	1	-	(1)
		4		6		3		3		4

The following interpretation (Figs 3 & 4) of the identified regional data is performed to illustrate the tight parallel of political atmosphere and civic growth. As explained later, the political climate forms the axis of the model proposed in this research. This analysis is intended to clearly exhibit political influence on all sectors of society.

Fig. 3 Political Fluctuations - as represented by Political Rights (blue) and Civil Liberties (pink).

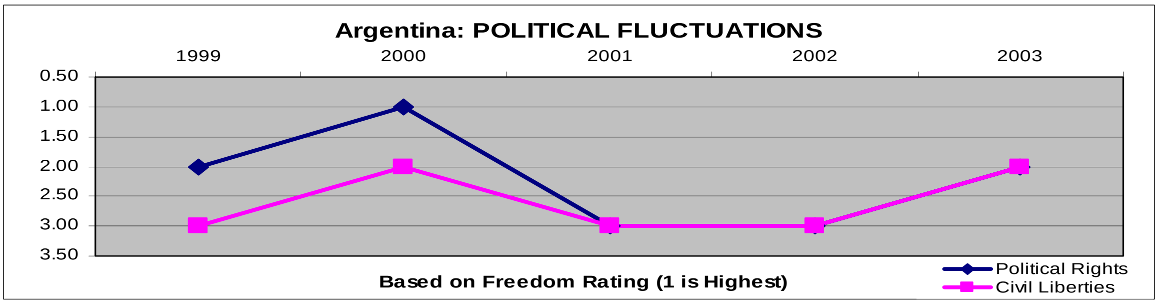
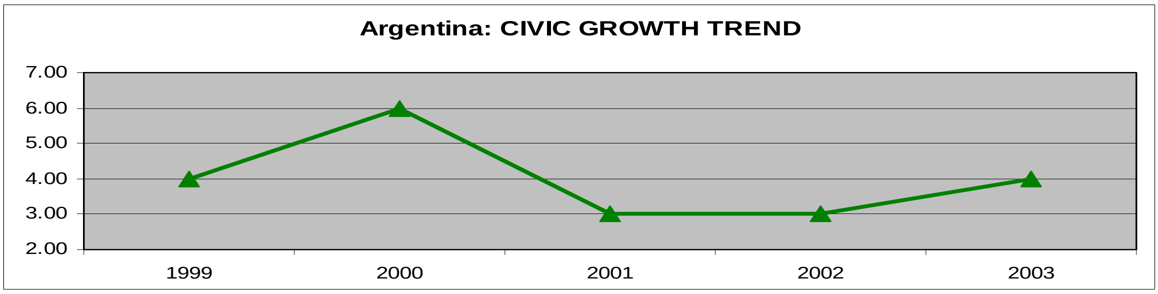


Fig. 4 Civic Growth Trends (based on information in Table 3)



When juxtaposed against the political trends identified earlier (Table 1), Figures 3 & 4 exhibit a distinct correlation between the civic growth trends and the political fluctuations. This further emphasizes the effect that shifts in political structure have upon a region. The intent of this exercise is to illustrate the hypothesized correlation between political conditions and regional growth. From this grouping of data, there will begin to appear cultural indicators that are otherwise not quantifiable. Therefore, it is important to identify a means by which to group this data to create a more complete picture.

UTILIZING THE DATA IN CONSTRUCTION PLANNING

The first thing established in this process was an illustration of recent political trends. This information is readily accessible through a series of databases worldwide. Comparing these fluctuations against trends in the civil sector demonstrated a tight correlation. Therefore, it is assumed at the outset that the political environment will have a significant impact upon the construction process.

Primary determinants of a successful construction project generally revolve around schedule, budget, resource/material allocation, and collaboration. When applying these to the political environment, some preliminary assumptions can be made. For instance, when laying out the construction schedule, an understanding of local political conditions due to labor relations or elements of unrest can dictate activity durations and anticipated lag time. Anticipated budget issues due to bureaucratic interference can be established in a cursory examination of local conditions. Access to certain materials due to tariffs or trade restrictions will help in determining resource procurement and allocation. Even details about the field management of human resources can benefit from a brief examination of local political conditions.

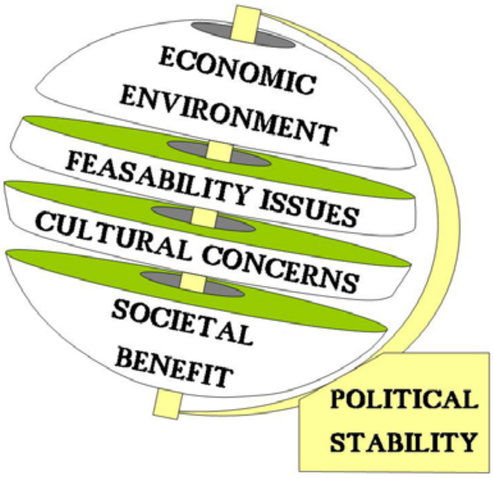
Beyond assumptions regarding political influence are some other discernable trends at this level in the research that can benefit further construction planning. In gathering the previous sets of data, a construction interest can begin to ascertain preliminary indicators of how these elements are going to react during the construction process. Information outside of purely economic data provides this more complete insight. In the test case of Argentina there appears to be a steady advance in technology as exhibited by increases in PC owners and internet users. Applying this to the arena of construction, the use of technology can then be advanced as a construction tool (scheduling, process management, etc.) from the beginning of a project. Another example of a distinguishable trend in the test case of Argentina would be a notable increase in the railroad system. A simple understanding of the transportation routes available to a project can provide an insight to the accessibility of labor and materials to a site.

The intended result of this research will be to provide a system to not only collect and examine raw data sources, but also to accumulate knowledge, to establish a database of information pertinent to the construction effort as an essential tool in the planning process and ultimate execution of a project. Historically, this would be addressed simply as a list of facts, analyzed, then disregarded after the information was incorporated in the decision-making. This attitude necessitated a means by which to channel these findings so that the construction planning decisions can begin to reflect a more complete understanding of local conditions.

THE SEMISPHERE MODEL

The Semisphere Model (Fig. 5) provides a means to focus raw data into a cohesive collection of regional facts. In doing so, this can begin to articulate the direction in which to focus the construction effort. By utilizing an accessible and coherent database, the construction team can start to understand resource allocation, scheduling issues, human resources, etc. Further, the construction team is able to quickly ascertain the political atmosphere and gauge how decision making is going to be effected on the project. What the Semisphere Model presents is an opportunity to collect regional statistics while recognizing the inherent influence of politics.

Fig. 5 *The Semisphere Model*



Findings are grouped into different areas based on some inherent similarities. The Semisphere Model breaks the data sets up into four distinct classifications, or "semispheres", the sum result of which will provide a cohesive conclusion upon which to base a business decision and to begin the process of detailing construction methods. As exhibited in Fig. 5, these semispheres are defined as Economic Environment, Feasibility Issues, Cultural Concerns, and Societal Benefits. No one is weighted more than the other, rather by being part of a unified whole they each contribute to a more complete understanding. While these are addressed as independent forces, it is important to note that they are all affected by political stability. Without a strong axis, these parts cannot exist in concert with each other and provide the same benefits as a unified whole.

The Semispheres

The local Economic Environment is an integral factor to a successful project. Examining the economic trends will immediately begin to identify the growth potential and resources available. Because this is the traditional indicator of regional health, data is readily available for research of the subject. The Semisphere Model ideology seeks to go beyond the conventional GDP figures and annual income per capita. To truly exploit the model, more abstract indicators can be used to derive the same conclusions. For instance, fluctuations in cable/satellite television subscriptions or mobile phone service per capita can show a growth in personal wealth. Other indicators such as these begin to paint a more comprehensive picture of the populace that is the primary intention of this model.

Feasibility Issues are primarily site-specific concerns. These issues can give a quick indication as to whether or not the site is worth developing, or whether it can support the proposed project. This category can be subdivided into major groupings such as infrastructure (utilities access such as gas and electric, potable water sources, wastewater management), access (paved access routes, nearby transportation/shipping centers, access to major transportation arteries), environmental issues (terrain, soil conditions, sustainability), and resources (available skilled labor, raw materials, access to heavy machinery). Analysis of the data gathered during the research period pertaining to feasibility issues will lend a better understanding to how the site will react to the project.

The category of Cultural Concerns primarily entails issues related to collaborating with another culture and the ability to interpret and recognize local traditions. These concerns generally involve the allocation and management of human resources. Being able to discern the normal workdays, working hours, job practices, and particularly recognized holidays is critical to proper scheduling. This information can be rather easily gathered; however, it is necessary to include this level of detail at this stage of the information gathering process to provide a more complete understanding of cultural issues that may influence the ultimate execution of the project.

The Societal Benefit of a project is not as readily quantifiable. This category of information is important due to the inherent underlying value it lends to a project. Public opinion and excitement generated by such recognizable indicators of progress can provide an unanticipated level of success. It would be valuable to identify these potential benefits early in order to further capitalize upon and amplify them through a deliberate implementation of certain construction methods. Some examples of societal benefits are job creation, community ownership of the project, or the unintentional creation of a landmark. Maintaining a focus upon these benefits while establishing a construction methodology will assure that a project recognizes these intangible levels of success.

TOWARDS AN INTERNATIONAL CONSTRUCTION MANAGEMENT SYSTEM

While the field of International Construction Management remains primarily an academic pursuit, the recent and expanding proliferation of available data presents an opportunity to begin to quantify this information and make it work within the parameters of a well-defined system. The Semisphere Model is anticipated as a first step in the development of these methods.

In this process, from the introduction of research parameters through the implementation of the Semisphere Model, the intent has been to go from a broad examination of a region to a more detailed understanding of a region's potential. By utilizing this process as such, the project team can begin to identify certain cultural and societal issues that can be incorporated into the construction methodology.

The practical application of this understanding will be indispensable as a tool in the decision making process and further as a guide to creating a construction methodology to coalesce long established methods with cultural incongruities.

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How Much Extra Does Sustainable Housing Construction Cost?

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Abstract
This paper gauges how much extra construction costs, when required to meet housing sustainability requirements. Housing construction in New South Wales (NSW) is the first in Australia to be subject to mandatory sustainability requirements. The NSW Department of Infrastructure Planning and Natural Resources has developed and mandated use of an online assessment tool 'BASIX' which acts as a sustainability index and sets scores required to obtain development approval in new single dwelling projects. Of note, dwellings must pass thermal comfort requirements, achieve at least a 40% reduction in water consumption and at least a 25% reduction in greenhouse gas (energy) emissions compared to a base model house. Cost differences were determined between 20 houses constructed to meet the BASIX sustainability criteria, versus 20 conventional houses. The research design identified and addressed the need to control extraneous variables that could affect the comparison. It was found that on average, the houses constructed to meet BASIX sustainability criteria cost 6.3% extra compared to conventional houses. Most of the cost related to water usage reduction because mandatory energy efficiency and thermal comfort requirements, implemented prior to BASIX, allowed conventional houses to almost meet BASIX energy and thermal requirements. The findings provide information for a more advanced debate concerning the capacity of individual home purchaser's to pay for sustainability - especially those on low incomes – versus the greater good that sustainable construction provides for the community as a whole. The paper recommends that findings be used for future benchmarking comparisons and to develop mechanisms for targeting where rebate assistance may be merited.

Keywords
sustainability, housing, construction, cost estimating

INTRODUCTION

A significant problem in today's world is how to provide a decent standard of living for the human population without destroying the life systems on which the very existence of humanity depends [Sandlund *et al.*, 1992]. The solution has been termed 'sustainable development' which can be defined as the use of natural resources without destroying the possibility for future generations of using the resources in the same way [Head, 2003].

Construction in general and buildings in particular, contribute to environmental problems through resource depletion, energy consumption, air pollution and the creation of waste [Spence, 1995]. The construction and operation of the built environment has a disproportionate impact on the natural environment relative to its role in the economy. For instance in the USA, it represents about 8% of Gross Domestic Product but the construction sector consumes 40% of all extracted materials, produces one third of the total landfill waste stream, and accounts for 30% of national energy consumption for its operation [Kibert, 2002]. As a result, the construction industry must look beyond the bottom line cost and seek options that will provide both the client and the community, something of lasting and intrinsic value. An example of attempts to address these concerns include the United States Green Building Council's rating system known as "LEED" - for Leadership in Energy and Environmental Design [USGBC, accessed 23/7/05]. A study pertaining to this, found that a mix of 25 "green" office buildings and 8 schools averaged 2% extra cost - but with an upper range of up to 7.5% extra cost - compared to conventional buildings [Kats, 2003]. This was based on costs calculated over a 20 year life cycle.

In 2004, the NSW Department of Infrastructure Planning and Natural Resources (Australia) introduced a similar tool referred to as "BASIX". It provides a building sustainability index and online measurement tool, for the mandatory assessment and approval of new single dwelling projects in New South Wales [DIPNR, accessed 23/7/05].

One aspect of debate about BASIX concerns whether mandatory sustainability features will decrease the affordability of housing. For instance, if design and construction costs become too expensive, then housing may become unaffordable – especially to first home buyers or those on low incomes. An alternative perspective is that some additional cost to the individual is merited, if it provides a greater good for the overall community.

On this basis, the purpose of this paper is to determine whether sustainable housing construction is more expensive than conventional housing construction and if so, by how much. By finding this out, a more informed debate can be conducted on how sustainable construction effects housing affordability.

CONTEXT CONCERNING SUSTAINABLE CONSTRUCTION

Though modern definitions of sustainable development can be broad reaching and can include dimensions such as ecological, economic and social dimensions [Kua & Lee, 2002]. Of the three, this study focuses on housing construction purely meeting ecological standards. In this context, Spence & Mulligan (1995) state that there are several ways in which to define a sustainable house:

- Climate appropriate passive solar design which minimises the need for artificial heating and cooling
- Site protection in design and during construction
- Exclusive use of products which are recycled or made from renewable resources
- Management of own waste on site, including grey water and black water
- Produce and efficiently manage electrical power
- Collect and efficiently manage water resources

An important reason for applying sustainable development to housing is because of the essential role it plays in enhancing global and local sustainability. Since the publication of the World Commission for Environmental Development report in 1987, it has been increasingly recognized that while sustainability is a global issue, its achievement requires and in fact hinges on local action [Chiu, 2003]. In particular, cities have become a focal point as this is where most economic activity takes place, and where employment, education and other services are offered. Simultaneously, cities are also the main consumers of natural resources and the main producers of pollution and waste. Recognizing the critical role of cities, the United Nations convened an earth summit in 1996, the Habitat II, with 'adequate housing for all' and 'ecological sustainable development in an urbanizing world' as the overall themes [Elander & Lidskog, 2000].

In recent years, clear trends have emerged in Australia that suggest the latest housing stock is - despite intentions to the contrary - becoming significantly less sustainable. Larger houses and lower occupancy rates are at the core of the problem. The average floor area of detached dwellings has increased by 53.8% in NSW from 1984-2003 [ABS 2005a]; simultaneously there has been a fall in the number of people per household from 2.6 in 1994 to 2.5 people per household in 2003 [ABS 2005b]. These factors combined with housing locations that are increasingly remote from public transport, and housing forms that are demanding more energy to heat and cool, pose a considerable sustainability challenge.

Kibert [2002] identifies three approaches to achieving changes in the way we use resources including economic incentives, alterations in social attitudes and change via government legislation or regulation. It is this third dimension that best describes the newly introduced BASIX tool (mentioned previously) which is mandated to assess and obtain development approval in new single dwelling projects. For the purposes of this research, BASIX offers an operational means for defining sustainable housing construction and as a result, the emphasis of this study is based on regulatory criteria for sustainability, rather than the likes of economic incentives or changes in social attitudes. An advantage of this approach is that it provides an objective basis for comparing sustainable and conventional housing construction costs.

MORE ON BASIX

BASIX aims to reduce the environmental impact of built development and to produce homes that are more comfortable and cheaper to run than most existing homes. Having said this, BASIX is not a rating tool that assesses post occupancy building performance, and clearly does not control occupant usage and behaviour. It is a tool which focuses on the potential of a building to perform as well as possible, determined by scoring features included at the design stage of a project [DIPNR, accessed 23/7/05].

To use BASIX, data are input via a web based interface relating to site area, gross floor area, roof area, number of bedrooms and landscaping area. For these areas, details on the design are sought pertaining to the dimensions of thermal comfort, water usage and energy usage. Adding or subtracting specific features will vary how well the design performs in these areas.

Once the required data are entered BASIX calculates whether the project passes or fails *thermal comfort*; reaches at least 40% reduction in *water usage*; and reaches at least 25% reduction in greenhouse emissions from home *energy* sources such as electricity, gas and wood fired heating. BASIX issues a certificate verifying whether a houses meets these minimum requirements, which is needed for an applicant to obtain development approval from the local approval authority [DIPNR, accessed 23/7/05].

At the time of conducting the current study (mid to late 2004) BASIX was designated to only deal with single dwelling projects, since then it's scope has been broadened to incorporate multi-dwelling projects as well. In addition, the base house used for calculating energy and water reductions has recently changed (in July 2005) from utilising only Sydney housing data, to now using state wide housing data, thus causing modifications to the way BASIX rates inputs and calculates scores (Note: the current research was based on the Sydney data).

Further to the above, BASIX requirements overlap with the pre-existing National Housing Energy Rating Scheme (NATHERS). NATHERS has been in place since the mid 1990s and requires development applicants to design houses of appropriate energy and thermal comfort levels, in order to obtain development approval [Ballinger 2003]. Findings using NATHERS can be plugged into BASIX instead of using the BASIX specific methods for determining score sin these areas.

Initial projections of cost increases caused by BASIX were commissioned prior to its introduction, by the Department of Infrastructure, Planning and Natural Resources. Allen Consulting [2003] estimated an $8,988 increase in the cost of a model 250m^2 home - using 20% energy reduction and 40% water reduction factors. The current study aims to extend these findings by studying a sample of real dwellings as well as applying the higher and more commonly used BASIX settings for Sydney (i.e. 25% energy usage reduction and 40% water usage reduction). The study also aims to present the findings in a more generalisable format by presenting the findings as a percentage increase on conventional construction costs.

RESEARCH METHOD

Given the previous discussion, BASIX was used to provide a measurement scale for determining if houses were definitively "sustainable" or "conventional", and the extent to which houses fell into respective categories.

Using data derived from BASIX for the two respective sets of houses, calculations were undertaken to determine average differences in costs between the two groups.

In undertaking the above, the research design was of extreme importance in order to suppress the influence of potentially extraneous variables. A method was devised which addressed the key issues. At the base of the problem was the simple fact that since BASIX had been introduced, conventional houses were no longer being built in NSW. Paradoxically, another problem was that at the time of gathering data (mid to late 2004) BASIX had only just been introduced so no completed houses were finished under the new standard, thus creating problems for gathering cost data on sustainable houses.

To deal with this, it was decided to adopt a strategy based on using houses built prior to the introduction of BASIX. The sampling concept attached to this strategy was to find a set of existing houses likely to pass the BASIX sustainability requirements; and another set that would probably not pass requirements. The selected houses were then to be run through the

BASIX tool to confirm whether they were in operational terms “sustainable” or “conventional” houses.

Still further development was required in the research design to prevent the previously mentioned concerns about extraneous variables. For instance differences in the timing and location of construction projects is known to effect construction cost comparisons. Further to this, differences in terms of the purchasing power and project management expertise of different contractors could also effect cost comparisons. Finally, the size and design specification of different houses was also likely to create differences.

These needs were controlled by using a single housing contractor who was able to provided 20 sustainable houses and 20 conventional houses. Both sets were built in the same 12 month period.

With regard to the above, the contractor was able to provide 20 detached houses built as part of the Sydney Olympic project constructed during 1999 and finished in 2000. These houses were part of an urban regeneration project and were specifically designed with sustainability principles in mind - as dictated by the “Green Games” theme assigned to the Sydney games [Head, 2003 p.26]. As an example, all houses from this development featured grey water recycling systems, stormwater recycling, water conservation devices, solar panels and large scale plantings of native grasses and trees. The houses were run through the BASIX software and were found to easily surpass minimum BASIX requirements, thus making them definitively “sustainable” for the purposes of the research.

A set of 20 conventional detached houses were obtained from the same contractor but from a nearby urban regeneration development. It was only 4 kilometres away (at Cabarita) and the location was very similar in terms of the market and demographic demand for housing in the area. As a result, the dwellings were of similar size i.e. 262.45m^2 average for conventional houses versus 247.55m^2 for sustainable houses. They were also built to a similar construction specification in terms of utilising slab on ground floors, brick veneer walls, two storey construction, tile and metal roof combinations, timber sun hoods, skylights and double car garages. Both sets of houses also included similar finishes internally and externally. Obviously sustainability features differed, but even so, the conventional houses still had some thermal comfort and energy saving features due to the requirements of the already mentioned National Housing Energy Rating Scheme.

Though a larger sample would have in some ways been preferable to the one obtained, the degree of control over unwanted variables provided benefits in terms of research design and a holistic perspective of cost impacts. As such, finding have limitation as dictated by the method used and in particular - using data from a single contractor. However, in attempting to generalise the data to a broader industry perspective, it can be said that the conventional houses - which form the basis for comparison in the study – averaged \$944.72/m^2 and this compares closely with a medium to high standard specification for housing, when compared with industry indicators (at the time) such as Rawlinson’s Construction Cost Guide (1999).

Given the previous discussion, construction costs from the two sets of houses were obtained directly from the contractor’s internal records to determine differences between sustainable and conventional houses. Care was taken to obtain production quantities i.e. what was actually ordered and what labour and supervision were actually paid for.

Finally, a sensitivity analysis was conducted to find out what elements of the sustainable houses impacted most on costs and whether any items could be deducted to reduce construction costs, while still complying with minimum BASIX requirements.

ANALYSIS

For the two sets of houses, analysis relating to the three dimensions that BASIX focuses on (thermal comfort, water reduction and energy reduction) is dealt with first, followed by a sensitivity analysis and finally, a cost comparison analysis.

Thermal comfort is dealt with categorically by BASIX as a pass or fail variable. Both sets of houses passed this criteria and in many ways this is not surprising due to the overlapping NATHERS program which requires thermal comfort standards be met. As result, there is no significant cost difference on this issue and most of the emphasis in the remaining analysis has been placed on water and energy reduction, which offers a higher degree of insight into measurable differences.

As mentioned previously, BASIX requires a minimum of 40% reduction in *water usage*. Findings indicate that the set of sustainable houses surpassed this with an average score of 44.2% but conventional houses fell well short with an average score of 11.2%. Though the gap between the two averages was large, being 33% points, the range between individual sets of scores was small, as may be expected from houses constructed within a single development, of a similar size and by a single contractor. For instance, the sustainable houses only ranged from 44-45% points, while the conventional houses ranged from 26-30% points.

Also mentioned previously, BASIX requires a minimum of 25% reduction in *energy usage*. Findings indicate that the set of sustainable houses far surpassed this with an average score of 44.35%, but conventional houses fell short by only 1% with an average score of 24.0 %. Obviously, this nearly meets the minimum BASIX requirements and it seemes this narrow margin is because the houses were designed to meet the pre-existing NATHERS scheme. Again, the range of scores for respective sets of houses was minimal, with sustainable houses only ranging from 41-46% points and conventional houses ranging from 23-25% points.

Sensitivity Analysis

A sensitivity analysis was carried out to determine design features making the most difference to water and energy efficiency in the set of sustainable houses, and to see if items could be removed to reduce cost, without compromising compliance with BASIX minimum standards. This was done by reprocessing the scores after removing individually targeted features – then re-costing the houses accordingly. Items to be deducted or modified were targeted on the basis that they were high scoring items in the BASIX system.

Table 1: Sensitivity analysis for water efficiency items

Item removed	Reduction in score	Does the house still comply with BASIX requirements	Cost difference
Grey water recycling system for toilet	-19.2%	No i.e. 44.2%-19.2% is less than	Not feasible,

cistern usage		the required 40%	therefore not costed
Grey water recycling system for garden watering	-11.2%	No i.e. 44.2%-11.3% is less than the required 40%	Not feasible, therefore not costed
Triple “A” low usage showerheads and toilets (AS/NZ 6400, 2003) i.e. use unrated fittings instead	-10.2%	No i.e. 44.2%-10.2% is less than the required 40%	Not feasible, therefore not costed

It can be seen from Table 1 that none of the selected water efficiency items could be removed without causing non-compliance with minimum BASIX water reduction requirements. To put this into further perspective, even if the lowest change item (i.e. “Triple A” rated showerheads and toilets) could have been removed without affecting compliance, the saving would have only been a minor $16/showerhead and $20/toilet compared to the conventional houses. A saving barely worth making. As such, it would also seem that significant cost savings on water efficiency features are unlikely to be possible for houses rating 4-5% points above the minimum BASIX requirements due to the inability to remove appropriately low scoring items.

A similar exercise was undertaken for energy efficiency items and this was of potentially greater interest because of the previous finding that the sustainable houses were so far above minimum BASIX requirements. As a result, there was significant potential to adjust the specification of energy efficient features down towards minimum BASIX standards, and in doing so achieve cheaper construction costs. Details are shown in Table 2.

Table 2: Sensitivity Analysis of energy efficiency items

Item removed	Reduction in score	Does system still meet BASIX requirements	Potential cost reduction
Remove Photovoltaic System	-7.35%	Yes i.e. 44.35% -7.35% is more than the required 25%	$5,500 (2.16%) per dwelling
Change hot water system from solar (Gas Boosted) to instantaneous gas hot water system (with 3 star energy rating)	-12.00%	Yes i.e. 44.35% - 12.0% is more than the required 25%	$983 (0.38%) per dwelling
Combined results	**-19.35%**	**Yes i.e. 44.35% - 19.35% is slightly more than the required 25% (i.e. 26%)**	**$6,483 (2.5%) per dwelling**

Given the tabulated findings, the photovoltaic system could be removed and the hot water system downgraded while still providing and energy usage score of 26%, a score just above the minimum BASIX requirement.

Construction Cost Comparison

Total construction costs for respective sets of houses were divided by floor areas to derive unit rates. The unit rates were then averaged to derive average unit rates as shown in Table 3. The above findings from the sensitivity analysis were used to adjust down the construction costs for the sustainable houses (refer final column of Table 3).

Table 3: Construction cost comparison (based on set averages)

Conventionally constructed houses			Sustainably constructed houses			
$/house	Area/house	$/m^2	$/house	Area/house	$/m^2	$/m^2 after sensitivity analysis
$247,942	262.45	$944.72	$255,093	247.55	$1,030.47	$1,004.28

As shown in the Table 3, the adjusted cost per metre square for the 20 sustainable houses was \$1,004.28/m^2 while the cost per metre square for the 20 conventional houses was \$944.72/m^2, equating to a difference of \$59.56/m^2. This difference relates to sustainable houses being 6.3% more expensive than conventional houses.

DISCUSSION

The research posed the question, *how much extra does sustainable construction cost (compared to conventional housing construction)*? For detached housing in Sydney, Australia, the difference at the time of collecting data was 6.3%. This figure – as demonstrated by the sensitivity analysis - will vary depending on whether the intention is to just pass minimum BASIX standards – as in this study - or attain higher levels. The main component causing the extra cost appears to be in meeting water efficiency requirements, because conventional houses already have elements of energy efficiency and thermal comfort via the pre-existing NATHERS scheme.

In general, the findings are a guide, valid only at a point in time and for a given research design. For example the projects used in the study, pre-date the introduction of BASIX and as a result, current building designs may utilise different and possibly more cost effective methods of meeting minimum BASIX requirements i.e. different economies of scale, market sentiments, installation systems and technologies. Further to this, and as alluded to early in the paper, the base model house used for calculating scores in BASIX has recently been modified; in addition, minimum compliance standard for energy usage are also due to be increased in mid 2006. This will add new cost ramifications. Finally, BASIX may in time take-on a more expansive view of sustainability including economic impacts, social implications and the life cycle costs of built development.

Of note, this study did not take into account life cycle costs because of it's focus on the affordability of construction at the time of purchase. A sequel to this study could cover this issue and in doing so, would enable the ability to dissect up-front construction costs and life cycle savings. Along a similar theme, the Federal Government has introduced Renewable Energy Certificates (RECs) and a Photovoltaic Rebate Scheme. Both schemes aim to allow life cycle energy savings to be recouped at the time of construction [ORER, (accessed 23/7/05), AGO, (accessed 23/7/05)]. Both schemes were excluded from this study because they were treated as add-on components in the overall construction cost structure. For instance the schemes involve third party transactions and RECs represent a type of currency where value fluctuates according to demand in the energy industry, not the building industry. The uptake of such schemes within the building industry is also unclear. Finally, the schemes tend to target upstream suppliers so it is unclear how much savings are lost with each progressive involvement in the supply chain, before eventually reaching the home purchaser. As a result, these schemes offer potential savings but at this point, are not necessarily quantifiable as standard deductions from construction costs. An individual study would assist in meeting this end.

The current study provides an objective albeit conditional indicator of extra costs for sustainable construction. It could be used as a basis for comparison and benchmarking with other studies. The information could also be extended to provide a more advanced debate concerning the capacity of individual home purchaser's to pay for sustainable construction, versus the greater good it provides for the community as a whole. To demonstrate, it is apparent from the study that house size influences the scores attained in BASIX, as does the number of occupants in the house. It would be useful to conduct a similar study to this one, using different sized houses. A graph could then show the extra construction cost for different (sustainable) house sizes, and this could then be used in conjunction with information on reasonable occupancy levels, to assist in targeting where rebate assistance is merited. Implementation of such an approach may also serve to discourage people building larger houses than necessary.

Under any scenario, the research design used in this study highlights the need to control extraneous variables that can effect cost comparisons. Issues include differences in: the timing of construction, project management skills, purchasing power, building size and design specification. Such issues should be taken into account when considering the validity of cost comparisons and in comparing the results from different studies.

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Proposal of indicators to monitor the performance of the civil construction production chain in Brazil

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Abstract
The objective of this paper is to propose indicators to monitor the performance of the civil construction production chain in Brazil, especially in housing construction. This proposal considers the results of a pioneering prospective study carried out in Brazil in 2002. The prospective study was performed by the Department of Civil Construction Engineering of Escola Politécnica of the University of São Paulo, and coordinated by the Ministry of Development, Industry and Foreign Trade of Brazil. The aims of this study were to configure a desired and viable future for the development of the chain, considering the 2003-2013 scenario, and to propose actions on the chain itself and on its institutional and organizational environment, aiming to improve its performance in the future, designing long-term development strategies for this sector. Initially, a summary of the prospective study in the housing production chain is presented. Then, the method to obtain the performance indicators proposed by the Brazilian civil construction sector are presented and analyzed. Considering the insufficiency of performance indicators in Brazil, it can be concluded that the proposal of indicators allowed advancement in the knowledge about the civil construction sector, providing subsidies for the sector to adopt a pro-active stance regarding its future, which will only be achieved through better knowledge and monitoring of its actual performance.

Keywords
housing construction, prospective study, performance indicators

INTRODUCTION

The objective of this paper is to propose indicators to monitor the performance of the civil construction production chain in Brazil, especially in housing construction. This proposal considers the results of a pioneering prospective study carried out in Brazil in 2002.
The prospective study was performed by the Department of Civil Construction Engineering of Escola Politécnica of the University of São Paulo, and coordinated by the Ministry of Development, Industry and Foreign Trade of Brazil. This study was inserted in the Brazilian Program of Industrial Technological Prospective and this program also has the support of the United Nations Industrial Development Organization, UNIDO.

The study was based on the concept of prospective view, which employs analyses of the past and the present to outline possible futures, build a desirable future or move away from an undesirable future. The prospective view opposes classic forecasting as it plays an active role regarding the future.

From this conceptual base it was possible to generate a clear and up-to-date thinking about how the civil construction production chain is positioned in relation to its own future. Trends, opportunities and elements that contribute to a better understanding of the behavior of the civil construction production chain were determined.

Firstly, a brief summary of the prospective study is presented. Secondly, we introduce the methodology and the criteria considered to design performance indicators for the civil construction production chain. The proposed indicators are then presented. Finally, conclusions and recommendations to obtain and monitor these performance indicators are presented.

THE PROSPECTIVE STUDY

The focus of the prospective study is the civil construction production chain, concerning the production and commercialization of urban housing units, and its aims are:

- to configure a desired and viable future for the chain development, considering the 2003-2013 scenario, starting from the present situation, and
- to propose actions on the chain itself and its institutional and organizational environment, aiming to improve its performance in the future, designing long-term development strategies for this sector.

The prospective study was divided into two parts: diagnosis and prognosis. The diagnosis involved: modeling the production chain as an industrial system, through successive and interconnected links, where each link adds transformations and value to the product, up to the final link, which is that of the consumer of housing; segmenting each link and the material and capital flows in the production chain; and producing a chain performance analysis in addition to the identification of important variables for its improvement, denominated critical factors.

The modeling, segmentation, and material and capital flows are already published in CARDOSO et al (2002). The performance analysis was presented in CARDOSO et al (2004).

The prognosis is carried out based on Delphi technique. According to this technique, a questionnaire is elaborated, based on the diagnosis, and sent to a team of specialists in the production chain (researchers, designers, entrepreneurs, suppliers, contractors, consultants, members of governmental agencies etc.). The questionnaire is composed by a set of questions, each followed by information regarding the past and present behavior of variables whose future behavior is to be predicted.

Most questions require the specialist to evaluate the behavior of variables, considering future scenarios in the social and economic context. The answers to the questions are then tabulated and analyzed, confirming whether a consensus was reached or not among specialists in relation to the behavior of variables. This technique allows trends of critical factors identified in the diagnostic phase to be determined.

The details of this technique and the results obtained are available in CARDOSO et al (2004). In CARDOSO et al (2005) an analysis of the prospective study results was presented considering the main strategies recently proposed by the sector itself, aiming at the improvement and the design of actions to develop the housing construction production chain.

All results of the prospective study are available in a recent publication of the Ministry of Development, Industry and Foreign Trade of Brazil, the book *O futuro da indústria da construção civil: construção habitacional* ("The future of the civil construction industry: housing construction") (MDIC, 2005). However, this publication is available only in Portuguese.

METHODS

The performance of a production chain requires a reference in order to establish its evaluation. This reference is constructed based on indicators, whose purpose is to simplify complex and abstract phenomena. Also called performance indicators, they represent the quantification of process performance criteria, generally correlating current situations with desired situations. The major contribution of indicators is to subsidize managers in decision-making at various hierarchical levels.

Some relevant aspects regarding performance indicators are: they must serve the various hierarchies; they must present the feature of aggregation, that is, they may be composed by and decomposed in other indicators that can meet the interests of the various hierarchical levels; they should be related to really essential or critical aspects; they must be easily understood and applied; and, finally, they must be low-cost. These parameters must be taken into account in all processes of performance indicator design.

The methodological criteria adopted in the process of designing the proposed performance indicators are presented below.

Critical factors in the civil construction production chain

The first criterion considered was to determine those aspects that were truly essential or critical to the performance of the housing construction production chain. This was conducted based on the synthesis of the critical factors identified in the prognostic phase of the prospective study.

In this phase 19 critical factors were selected from the 61 obtained in the diagnostic phase. This selection was made by evaluating the impact of the identified limitations and opportunities on the chain performance. Those critical factors of greatest impact correspond to the future goals of interventions aiming at an improvement in the performance of the civil construction production chain.

The table below presents the 19 critical factors, which correspond to 56 performance indicators that had been initially determined in the diagnostic phase. These critical factors are divided into three main sets: accessibility to housing, quality of housing and, finally, technology and management. And they are also connected to five performance criteria: Equity (Eq), Quality (Q), Efficiency (Ef), Competitiveness (C) and Sustainability (S).

Table 1. Critical factors of the civil construction production chain

Critical factors	**Initial number of performance indicators**	**Eq**	**Q**	**Ef**	**C**	**S**
Critical factors of Accessibility to housing	**16**					
Accessibility	7	X				
Financing availability	4	X				
Plot availability	1	X				
Informal production	1	X	X			X
Support to self-construction	0	X	X			X
Regulation and coordination ability	0	X		X		
Housing deficit	3	X				
Critical factors of Quality of housing	**10**					
Housing product quality	2		X			
Technical normalization	0		X			
Organizational and institutional support to quality	2		X			
Knowledge of consumer needs	5		X		X	
Components and material compliance	1		X			
Critical factors of technology and management	**30**					
Project	6		X	X	X	
Management	1		X	X	X	
Barriers to technological improvement	2			X	X	
Productivity	4			X	X	
Losses and waste	2			X		X
Construction cost	15			X	X	
Researches	0		X	X		X

The critical factors of accessibility to housing are related to the criterion of equity and the actions required to overcome such factors mainly lie in the political-institutional environment of the production chain, especially in terms of housing policies, financing, regulation and coordination, and urban policies. Accessibility also involves variables of macro-economic and social policies that lie outside the scope of the production chain environment, such as interest rate and income distribution.

Critical factors of quality improvement in housing products are basically connected to the quality criterion and involve variables located mainly in the institutional and organizational environment of the production chain, such as technical normalization, compliance, knowledge of consumer needs, diffusion of quality programs. They also involve behavioral change in the links of the production chain, mainly regarding compliance and normalization.

Finally, critical factors of technology and construction management basically refer to efficiency and competitiveness criteria, involving variables that depend on the links of the production chain itself (such as project, management, types of contracts), on its institutional and organizational environment (support to mechanization, technological research, modernization of labor relations) and also on the macro-economic and social environment (modernization and competitiveness of the economy, employment and salary raise).
The variables described above, referring to each set of critical factors, are the essential or critical aspects that must be represented in the performance indicators to be proposed. Therefore, these indicators should measure the performance of these variables, which are considered critical to the civil construction production chain.

“Aggregation” of performance indicators

In Table 1 it can be observed that some of these variables are already related to one or more performance indicators, as in the case of the critical factor “Accessibility”, which presents seven indicators that were identified in the diagnostic phase.

In the Brazilian civil construction sector, performance indicators are insufficient and precarious. As a rule, only the major aggregates are available, but in general with a lack of full details required to allow an accurate performance evaluation of their production chain. Some of the indicators collected in this phase were generated only occasionally, with few historical series being available, and those that were actually available normally covered relatively short periods of time. In the case of the “Accessibility” indicators, three of them exist and can be obtained, and four were generated occasionally and there are not any values available.

The set of indicators identified in the diagnostic phase must be analyzed from the perspective of the second criterion under consideration, that is the aspect of “aggregation” of indicators. According to this criterion, the indicators proposed should be composed by indicators already existent and available. This feature may influence the decrease in the costs to obtain indicators and allow their use at other hierarchical levels, since the indicator may, in this sense, be decomposed in lower levels.

This criterion could be applied to nine out of the 19 variables in Table 1, as they presented more than one indicator identified in the diagnostic phase. Due to the space available, this process is not described in this paper.

Objectives and targets of performance indicators

The third criterion considered is to set objectives and targets to the proposed indicators. The objectives represent the needs and expectations of the civil construction production chain, and the targets represent the performance levels of each variable (critical factor) that are expected to be reached in a determined future.

The objectives of each indicator are formulated by defining the desired evolution of the variables composing the three sets of critical performance factors: accessibility to housing, quality of housing and, lastly, technology and management. Hence, each objective represents the definition of a demand, which may be technological or non-technological, that determines views of the desired future in the long term.

Targets are formulated based on the main results of the prospective study, that is, the tendencies of the critical factors identified by applying the Delphi technique of technological foresight. These tendencies represent targets that are feasible, since they were obtained after consensus among specialists of the civil construction production chain.

In the prospective study tendencies for three possible future scenarios were determined: pessimistic, biased and optimistic, which presented differences in social and economic context. The targets adopted in this paper consider the tendencies observed in the optimistic scenario. Most targets represent qualitative estimates of the critical factors, due to the inexistence of indicators that could represent the desired levels.

Proposed performance indicators

According to the criteria summarized previously, the following list of proposed indicators was drawn, related to the three sets of critical performance factors (Tables 2, 3 and 4). The tables present the objectives of the indicators, which bear a relation to the desired evolution of the critical factor, and the evaluation of availability of the proposed indicators, that is, if the indicators already exist and are fully available in the proposed format (A), if they exist but are scattered, outdated or hardly available (HA), or, finally, if the indicators are non-existent (NE).

For each indicator or critical factor, the current situation and its respective target identified in the prospective study are also presented. The targets were estimated for 2013.

Table 2. List of proposed indicators – Accessibility to housing

PROPOSED INDICATORS (PI)	UNIT	CRITICAL FACTORS	OBJECTIVE	CURRENT SITUATION	TARGET	AVAIL.
Price of square meter/ population's income range	R$/m^2	Accessibility	Increase	Low/ Very low	Medium/ High	HA
Number of financed units/ Number of produced units (family income up to five times the minimum wage)	%	Financing availability	increase	Very low	High/ Medium	HA
Potential indicators should include indexes of political, technical, tax, legal and financial support to the availability of land and urban infrastructure		Plot availability	increase	Very low	Medium	NE
Informal production – incidence concerning total housing production	%	Informal production	decrease	60	44	HA
Should include technical, economic and social assistance, and the development of technologies for self-construction		Support to self-construction	increase	Very low	Medium/ High	NE
Should include programs, support and partnership policies between governmental and business institutions.		Regulation and coordination ability	increase	Low/ Medium	High/ Medium	NE
Urban housing deficit	millions of units	Housing deficit	decrease	5.4	3.8	A

Table 3. List of proposed indicators – Quality of housing

PROPOSED INDICATORS	UNIT	CRITICAL FACTORS	OBJECTIVE	CURRENT SITUATION	TARGET	AVAIL.
Number of companies certified by quality programs / Total of companies (constructors)	%	Housing product quality	increase	Unsatisfactory	Regular	A
Should include compliance indexes, updating and amplification of technical norms		Technical normalization	increase	Insufficient	Sufficient	NE
Should include indexes of support to control, certification, normalization and organizational research for quality		Organizational and institutional support to quality	increase	Weak/ Very weak	Strong/ Medium	NE
Should include indexes of product differentiation (types of product, prices, means of purchasing, etc.)		Knowledge of consumer needs	increase	Low/ Medium	High/ Medium	NE
Compliance index of construction materials	%	Components and material	increase	Medium/ Low	High/ Medium	A

		compliance				

Table 4. List of proposed indicators – Technology and management

PROPOSED INDICATORS	UNIT	CRITICAL FACTORS	OBJECTIVE	CURRENT SITUATION	TARGET	AVAIL.
Should include indexes of coordination, standardization and project rationalization		Project	improve	Unsatisfactory/ Regular	Satisfactory	NE
Should include indexes of organizational structuring and management capabilities of companies		Management	improve	Little advanced	Advanced	NE
Should include indexes of innovation, research and industrialization of construction		Technological improvement	increase	Little advanced	Advanced	NE
Productivity (residential construction)	hours per m^2	Productivity	increase	45.0	36.4	HA
Should include indexes of material, capital and labor waste in construction site		Losses and waste	decrease			HA
Total cost Cost of materials Labor costs	US$* per m^2	Construction cost	decrease	Workmanship=56.17 Material=77.27 Total=133.44	Constant / Little increase	A
Should include indexes of demand and resources invested in research, as well as indexes of integration between production sector and research centers.		Researches	increase	Low/ Very low	Medium/ High	NE

*Reference values 2002: US$ = R$3.00

Out of the 19 critical factors, four present existent and available indicators (A), five present indicators that are existent but outdated or not easily available (HA) and ten do not present existent indicators (NE). It was also realized that distribution is homogeneous among the three sets of critical factors, which reflects the insufficiency and precariousness of performance indicators in Brazil. Regarding the inexistent or hardly available indicators, the aspects that should be included by potential indicators were suggested.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the prospective study and the methodology adopted in this paper, it was possible to propose nine performance indicators for the civil construction production chain, out of which four are available and five are hardly available. As for the other ten critical factors, it was possible to determine the relevant aspects that should be considered by potential indicators.

Considering the insufficiency of performance indicators in Brazil, it can be concluded that the proposal of indicators allowed advancement in the knowledge about the civil construction sector, providing subsidies for the sector to adopt a pro-active stance regarding its future, which will only be achieved through better knowledge and monitoring of its actual performance. The next step of the prospective study is to propose the creation of a national observatory to monitor the performance of the sector.

The methodology adopted in this paper illustrates an initial base for the process of performance indicator design and which can be summarized in three main steps: identification of critical performance factors, analysis of aggregation of indicators, and, finally, definition of objectives and targets for the indicators. In order to monitor the indicators this procedure must be regarded as an ongoing improvement process, in which indicators and their critical factors must be reviewed periodically.

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Requirements for Economic Sustainability in the Yemen Construction Industry

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Abstract
The construction industry of Yemen is experiencing economic and technical problems, which permeate most aspects of the industry. In addition, construction procedures consume excessive capital, time and resources that have a direct flow-on effect for the national economy and the nation's socio-economic development. Macroeconomic problems in unemployment, inflation and an inequitable balance-of-payments all add to the existing difficult economic situation in the construction industry. Further, the lack of appropriate infrastructure, weak and inefficient legal, administrative and financial institutions is also major contributor.

The recent global shift to sustainable development requires that the construction industry in Yemen initiate important strategic developmental policies in order to meet future demand for economical and sustainable development.

Based on a previously conducted survey into the existing local development barriers and moreover on a census of experts opinions and discussions on a set of developmental policies and strategies, this paper establishes a comprehensive list of requirements and recommendations integrated with cultural aspects and hardships of Yemen to initiate the process to economic sustainability.

Keywords
Yemen, construction industry, policies, economic sustainability, process requirements.

INTRODUCTION

The construction industry as it plays an important role in the economy, and the activities of the construction industry are also vital to the achievement of the national socio-economic development goals of providing shelter, infrastructure and employment. However a report by the UNIDO (1993) has shown that little consideration is given to the construction industry by development planners and policy makers. There are problems and difficulties facing construction industries in developing countries, and the expected measures to manage them have been extensively investigated and many studies and recommendations have been made for action to address these difficulties [Turin (1973), UNCHS (1981), World Bank, (1984), UNCHS (1984), Wells, (1986), Ofori (1994) and Ofori (2001)]. The governments of some developing countries have implemented some of these recommendations, however, results have been disappointing and the problems continue [(Ofori (1993) & Kirmani (1988)]. It was suggested that the possible reason for the lack of progress was the absence of measurable targets in construction industry development programmes to guide and assess, at intervals, the success of their implementation [Ofori, 2001]. Ofori (1994) also commented on the reasons for this lack of progress in implementing these recommendations, claiming that it is due to the inappropriateness of some of the recommendations and the initiatives adopted.

Although, economic gain has been the driver for much of the unsustainable development that has occurred in the past, and the use of labour and raw materials was considered endless, nevertheless at the present these has to be sustained and the whole construction industry must move towards sustainability. Although Economics is known as the study of allocation of resources with competing and challenging uses; economics, to be relevant and applicable to sustainability, should not simply refer to Gross National Product, exchange rates, inflation, profit, etc. Economics is important to sustainability because of its broader meaning as a social science that explains the production, distribution, and consumption of goods and services. Thus sustainable economy consists of sub-themes, such as [Khalfan, 2000]:

- Investment in people and equipment for a competitive economy,
- Job opportunities,
- Vibrant local economy,
- Services are accessible which reduces use of transportation,
- Creation of new markets and opportunities for sales growth,
- Cost reduction through efficiency improvements,
- Reduced energy and raw material inputs, and
- Creation of additional added value, etc.

What's more the key contribution of the construction industry to economic sustainability should be manifested through:

- sustained and efficient use of resources and materials;
- sustained employment opportunities in all construction phases and
- sustained investment and capital formation opportunities for the economy.

While it is agreed that we share a common goal for achieving a state of sustainability, the developing world, with its great diversity of cultures, realises there are different ways of defining and meeting this goal and be best determined at a local level. A shift to sustainability will not be motivating if it is to be costly, problematic and is not within the local capabilities and facilities. Similarly, the suggested actions have to grow from local initiatives, making use of local strengths and addressing local barriers. Chapter 28 of Agenda 21 specifically addresses the way in which local authorities will implement this plan of action. Ensuring implementation at the local level was deemed critical because 'so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities' [UNCHS, Habitat, 2000]. Chapter 28.1 called upon local authorities to work with their local communities to prepare Local Agenda 21 plans and local strategies for sustainability by the end of 1996. Because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and cooperation of local authorities will be a determining factor in fulfilling its objectives, as local authorities construct, operate and maintain economic, social and environmental infrastructure; oversee planning processes; establish local environmental policies and regulations; and assist in implementing national and sub-national environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilising and responding to the public to promote sustainable development. The International Council for Local Environmental Initiatives [ICLEI, 1997] defined Local Agenda 21 (LA21) as:

> *A participatory, multisectoral process to achieve the goals of Agenda 21 at the local level through the preparation and implementation of a long-term, strategic action plan that addresses priority local sustainable development concerns.*

METHODOLOGY

In assessing the efficacy and value of the overall methodology employed in this investigation, it should first be emphasised that the objective was to shed light on the existing issues of the local construction sector in Yemen and then formulate the essential list of process requirements and recommendations for attaining economic sustainability development in the construction industry. The methodology used is based on the subsequent and previously conducted investigations:

- Data collection
- Survey on the local industry
- Policy selection and
- Delphi method for ranking and evaluating the policies

Data Collection

Literature and data collection was performed to build the necessary background on the country's national economic and cultural situation.The broad data collected and reviewed has revealed that there are macroeconomic problems in unemployment, inflation and external debts. All associated with a shortage of information and a lack of infrastructure [Sultan & Kajewski, 2003a&b].

Key statistics on Yemen and its construction industry show that value added in construction decreased from 8 in 1975 to 3.4 % in 2003, and it employs 6.6% of the total working manpower. The Second Five Year Plan (SFYP) as proposed by the World Bank (2002) envisages an average annual increase in construction activities of 11% and as a result the sector's share in GDP is planned to increase from 4.2% in 2000 to 5.5% in 2005. The construction sector is ranked 8th in its average relative contribution to GDP during the period 1990 to 2001. The average contribution to the GDP was 4.1%, compared with 29.5% for mining and quarrying, 15.1% for agriculture and fishing, manufacturing 11% and transportation 7.1%. Even before oil dependence, the construction industry made a moderately low contribution according to the Central Bank Annual Report (2002) with a negative balance of payment of over US$ 29.9 million.

Based on this relatively weak economic contribution by the construction industry and other issues are all an indication that the construction industry of Yemen is experiencing economic and technical problems. On top of that, the construction procedures also waste or rather consume excessive capital, time and resources that have a direct flow-on effect for the national economy and the nation's socio-economic development. All has raised the concern that the construction industry in Yemen is obliged to change its approach in order to meet future demands for any sustainable and economical development, moreover necessitate the appropriate selection and implementation of policies/strategies to guide this development [Sultan & Kajewski, 2004 & 2005]. Stretching out this paper put a set of necessary process requirements to facilitate successful implementation of these development policies. It is considered that without including these requirements and recommendations it would be difficult to implement sustainable development in Yemen.

Survey on the Local Industry

The survey on the local industry was performed and has recognized the technical barriers and economic bottlenecks facing the local industry development. The general conclusion on the barriers of development came as institutional and administrative weakness, in all forms of bureaucracy and corruption, followed by the lack of infrastructure required for economic activities and human settlements integration and well being, third was law and legal matters followed by financial and funding issues [Sultan & Kajewski, 2004]. The most important factors causing high construction costs were identified as imported materials, inflation and unstable economy and construction waste.

The survey concluded that there is an urge for institutional and administrative and human development to facilitate and monitor any required development. Construction regulations and laws can affect the choice and quality of the materials and will enable the designers to have more confidence in executing optimum designs. Monetary and fiscal policies should be designed to facilitate economic activities, control market prices, inflation. Moreover, the local development of the construction material industries should be adjusted and controlled by new and adequate choice and implementation of policies and strategies that provide development to local material industry and reduce consumption of foreign exchange. The adoption of explicit strategies and policies to reduce the impact of unemployment should be implemented through appropriate and more thoughtful labour employment. Yemen should seek to improve on the labour input in construction and only adopt those technologies that are relevant. The development of the construction sectors in Yemen should be aiming on optimising the utilisation of indigenous construction related resources and materials in their efforts to improve optimise their utility, uses and minimize or control importation [Sultan & Kajewski, 2004].

Policy Selection

The previous sections outlined the current situation on local requirements and constraints of the construction industry in Yemen and the need for appropriate institutional and legal reforms, economical solutions, effective technologies, appropriate type of construction systems, designs and construction materials or changed practices. Furthermore has pointed out that appropriate policies are required to stimulate and sustain economic development of the construction of Yemen.

Initially a range number of policies were selected[1]; the author's observations and knowledge on the local industry, and discussions with some professionals, the number of policies were rationalized to eight most appropriate and needed policies. The objective behind these policies is to attain progress aligned with sustainable development approach and to consider what is available. Some of other policies that were found less important and/or found beyond the research's' capacity, such as urbanisation and private sector intervention policies were put for further investigation and can be

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It has been realized that there is a need to initiate the role of government control over sustainable economic activities through the use of efficient and suitable administrative, legal and economic measures. Fiscal policies appeared to be prominent and were used extensively to encourage good sustainable practice in the construction process. The construction industry in Yemen is also very dependent on the importation of construction components and materials, thus necessitating the search for policy and strategy alternatives to consider what is available, and what can be developed, given adequate funding and resources. It is seems necessary to combine the use of administrative measures with appropriate economic and legal means for enhancing Yemen's overall capacity to deal with issues concerning economic and technical developments to move towards sustainable development.

The eight policies and strategies selected are listed as follows:

- Labour-intensive construction policies.
- Energy-efficient policies in design and construction.
- Credit and funding policies on selected projects.
- Local materials protection policy.
- Strategies for sustaining affordable infrastructure projects.
- Strengthening the law and regulations in construction and land affairs.
- Pricing policies and market control.
- Improve administration and institutional effectiveness and reduce all forms of bureaucratic procedure.

Up to this point the methodology have confirmed the selection of the most required policies and strategies, and were subjected to a ranking process to establish a consensus amongst a panel of Yemeni experts on the importance and possible implementation of each policy.

Delphi

An iterative group consensus Delphi method was used [Sultan & Kajewski, 2005] to establish the priorities of the previously selected polices according to the experts' opinions. The Delphi method was used as a popular qualitative forecasting approach to obtain the consensus of opinion among a group of Yemeni experts to rank these policies in terms of their priorities required in the development process towards economic sustainability in the construction industry. Also each specific policy is discussed, in terms of its possible implementation in Yemen, and the rationale for some of the preferences made by the experts in their rankings. Discussion with experts has also indicated that some policies are not applicable or difficult to implement at present. Although the sustainable development agenda is a long-term strategy, the method narrowed to the short and medium development forecast required in the transformation process.

The Delphi method investigation has concluded that the attainment of economic sustainability in the construction industry in Yemen is fixed to [Sultan & Kajewski, 2005]:

- fragile and corrupted institutional and administrative constraints,
- legal and regulatory practice weaknesses; followed by
- socio-economic barriers in the form of infrastructure shortages.

Despite the low ranking the design policy has gained, some experts indicated that the policy should be encouraged for the reason that, this policy implementation is approachable and manageable, especially when adapting traditional methods or materials. The policy of local materials protection was not strongly supported in view of the fact that the construction industry in Yemen is very dependent on the imports of construction materials the material industry is not ready to for an immediate takeover to fulfil the market demands. As well, the experts did not vigorously pursue the labour-intensive policy, to promote some local economic sustainable employment. This are due to productivity, cost and management problems associated with labour-intensive policy programmes. The fiscal, monetary and pricing policies to control unsustainable activities or products have not gained the support of the experts. Finally, despite the need for a financing system to facilitate credit, experts felt that funding through easy monetary and credit policies are not appropriate approach because of the existing lack of laws, regulations and the existence of corruption.

PROCESS REQUIREMENTS AND RECOMMENDATIONS

Based on the previous inclusive investigations and findings on existing development barriers in the Yemen case, the discussions and analysis of the experts' opinions on policies, subsequent development process requirements and recommendations are formulated for construction industry in Yemen:

- The obvious need for institutional and administrative development and human quality obligations within a reformed legal environment is an appropriate starting approach for Yemen. Institution building and creating the appropriate level of control over corruption via good legalisation seems essential to any intended development. The availability of appropriate and efficient administrative procedures and a reduction in bureaucracy will facilitate economic activities and development process. Institutional development should eliminate current local constraint by facilitating appropriate sustainable practices and raise investors and participants' confidence.
- The enforcement of laws and regulations are an essential factor in controlling the development process of the construction industry and associated industries. This is also needed to control illegal and unsustainable construction and economic activities and provide functional requirements for sustainable building designs and construction, stability and risk minimisation in the construction business.
- Sustaining an adequate supply of affordable infrastructure is considered necessary in the process for achieving efficient and economically sustainable construction development. The construction industry could reduce some socio-economic problems through sustainable industrial strategies such as cheap but effective locally based methods of providing infrastructure and affordable human settlements. Integrated planning is also essential to increase the distribution of affordable projects and minimize economical and environmental

disasters associated with major projects as is always experienced in Yemen. Poor investment decisions with respect to the choice of infrastructure projects always have devastating effect on the economy. Hence, comprehensive and detailed investigations for future projects and their impact on the economy and environment are needed.

- Reducing costs and energy consumption via sustainable designs and construction will necessitate the community acceptance, changes in engineering attitude and the education syllabus. Standards and specification guidelines must be established. Moreover, setting and implementing construction models and demonstrating sustainable projects for any government-sponsored projects by international organisations can effectively give support in this direction.
- The materials industry has to develop a more liberal and fair open market; however, this should be with the state control over selective imported materials. Import controls and fiscal mechanisms of taxation should be implemented mainly on imported material that is in direct competition with the locally manufactured low energy materials.
- Using fiscal and pricing measures as incentives towards sustainable construction will be inadequate in the short to medium-terms, especially where construction firms are unregistered and operate largely within the informal and unregulated sector of the economy. The market also lacks the information or market control to enforce the implementation of any pricing policies or market-oriented policies which influence the costs of particular forms of construction are of less significant influence.

ADDITIONAL REQUIREMENTS

Additionally to facilitate an economically sustainable construction industry in Yemen the following short to medium-term requirements are proposed by the author:

- It is necessary to improve the competence and ability of government human resources at all levels to play an active role in the sustainable development.
- Construction and economic activity manuals and guidelines should be established to streamline bureaucratic procedures.
- In the context of the decision-making process, the establishment of adequate and appropriate information and statistics is considered to be the basis for sustainable success and development.
- The Yemen construction industry should put more effort into minimizing resource wastage occurring within the execution of construction projects, decisions should be based upon competent and well-organized planning to prevent selection the low quality projects, and so minimize maintenance and life cycle costs with these associated projects.
- Efforts should be concentrated on the quality production and use of local low energy materials. The government and the private sector should study and initiate more research on the use of local materials and the recommended measures for their development. As the modern construction industry will be relying on imported materials for some considerable time to come, the local industry should best adopt practices that utilize renewable resources and materials with low embodied energy.
- Establishing a standardized market system in order to allow market mechanisms to play a fundamental role in resource allocation.
- Engineers must acquire the skills, knowledge, and information on sustainable development. The promotion of sustainable development demands that engineers cultivate an

understanding of the economical, social and environmental issues, risks and impacts on the community.

IMPLICATIONS FOR FURTHER RESEARCH

Discussions with experts have elicited a variety of views to further investigate the following policies and issues:

- Investigate the best process for the government to change institutional and legal systems to enhance sustainable development.
- Investigate to wether the government should sustain and support small business enterprises and local firms for economic development or rather promote larger local firms.
- Will affordability be a major issue in sustainable economic activities?
- Investigate the effect of lean construction methodologies.
- Establishing methods to effect public perception towards sustainable development.
- Investigate policies aimed at the overall maximization of domestic employment to reduce poverty
- Policies aimed at encouraging foreign and local investors intervention in infrastructure projects
- Future policies and strategies on urbanisation.
- Policies aimed at integrating and improving the informal sector

The fact is that Yemen will not be able to integrate the newer sustainable technologies into low-income communities for a long time. However, Yemen has a long tradition of construction that is more sustainable and better suited to local conditions than that introduced by imported technologies. Therefore, another key area for research is to identify these construction practices and materials and develop them further to provide an improved standard of living, while providing low-income communities with the opportunity to create livable and inhabitable settlements while sustaining their cultural heritage.

CONCLUSION

Investigation into the construction industry of Yemen has shown that the attainment of economic sustainability within the existing local institutional, technical and economical difficulties needed the establishment of integrated policies, at the same time, for the successful implementation of these policies; there are needs for interrelated requirements and recommendations within this development process. This paper has suggested these process requirements and actions based on the current local conditions and on the policy rankings and discussions with experts.

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Requirements for Economic Sustainability in the Yemen Construction Industry

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Abstract

The construction industry of Yemen is experiencing economic and technical problems, which permeate most aspects of the industry. In addition, construction procedures consume excessive capital, time and resources that have a direct flow-on effect for the national economy and the nation's socio-economic development. Macroeconomic problems in unemployment, inflation and an inequitable balance-of-payments all add to the existing difficult economic situation in the construction industry. Further, the lack of appropriate infrastructure, weak and inefficient legal, administrative and financial institutions is also major contributor.
The recent global shift to sustainable development requires that the construction industry in Yemen initiate important strategic developmental policies in order to meet future demand for economical and sustainable development.
Based on a previously conducted survey into the existing local development barriers and moreover on a census of experts opinions and discussions on a set of developmental policies and strategies, this paper establishes a comprehensive list of requirements and recommendations integrated with cultural aspects and hardships of Yemen to initiate the process to economic sustainability.

Keywords

Yemen, construction industry, policies, economic sustainability, process requirements.

INTRODUCTION

The construction industry as it plays an important role in the economy, and the activities of the construction industry are also vital to the achievement of the national socio-economic development goals of providing shelter, infrastructure and employment. However a report by the UNIDO (1993) has shown that little consideration is given to the construction industry by development planners and policy makers. There are problems and difficulties facing construction industries in developing countries, and the expected measures to manage them have been extensively investigated and many studies and recommendations have been made for action to address these difficulties [Turin (1973), UNCHS (1981), World Bank, (1984), UNCHS (1984), Wells, (1986), Ofori (1994) and Ofori (2001)]. The governments of some developing countries have implemented some of these recommendations, however, results have been disappointing and the problems continue [(Ofori (1993) & Kirmani (1988)]. It was suggested that the possible reason for the lack of progress was the absence of measurable targets in construction industry development programmes to guide and assess, at intervals, the success of their implementation [Ofori, 2001]. Ofori (1994) also commented on the reasons for this lack of progress in implementing these recommendations, claiming that it is due to the inappropriateness of some of the recommendations and the initiatives adopted.

Although, economic gain has been the driver for much of the unsustainable development that has occurred in the past, and the use of labour and raw materials was considered endless, nevertheless at the present these has to be sustained and the whole construction industry must move towards sustainability. Although Economics is known as the study of allocation of resources with competing and challenging uses; economics, to be relevant and applicable to sustainability, should not simply refer to Gross National Product, exchange rates, inflation, profit, etc. Economics is important to sustainability because of its broader meaning as a social science that explains the production, distribution, and consumption of goods and services. Thus sustainable economy consists of sub-themes, such as [Khalfan, 2000]:

- Investment in people and equipment for a competitive economy,
- Job opportunities,
- Vibrant local economy,
- Services are accessible which reduces use of transportation,
- Creation of new markets and opportunities for sales growth,
- Cost reduction through efficiency improvements,
- Reduced energy and raw material inputs, and
- Creation of additional added value, etc.

What's more the key contribution of the construction industry to economic sustainability should be manifested through:

- sustained and efficient use of resources and materials;
- sustained employment opportunities in all construction phases and
- sustained investment and capital formation opportunities for the economy.

While it is agreed that we share a common goal for achieving a state of sustainability, the developing world, with its great diversity of cultures, realises there are different ways of defining and meeting this goal and be best determined at a local level. A shift to sustainability will not be motivating if it is to be costly, problematic and is not within the local capabilities and facilities. Similarly, the suggested actions have to grow from local initiatives, making use of local strengths and addressing local barriers. Chapter 28 of Agenda 21 specifically addresses the way in which local authorities will implement this plan of action. Ensuring implementation at the local level was deemed critical because 'so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities' [UNCHS, Habitat, 2000]. Chapter 28.1 called upon local authorities to work with their local communities to prepare Local Agenda 21 plans and local strategies for sustainability by the end of 1996. Because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and cooperation of local authorities will be a determining factor in fulfilling its objectives, as local authorities construct, operate and maintain economic, social and environmental infrastructure; oversee planning processes; establish local environmental policies and regulations; and assist in implementing national and sub-national environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilising and responding to the public to promote sustainable development. The International Council for Local Environmental Initiatives [ICLEI, 1997] defined Local Agenda 21 (LA21) as:

> *A participatory, multisectoral process to achieve the goals of Agenda 21 at the local level through the preparation and implementation of a long-term, strategic action plan that addresses priority local sustainable development concerns.*

METHODOLOGY

In assessing the efficacy and value of the overall methodology employed in this investigation, it should first be emphasised that the objective was to shed light on the existing issues of the local construction sector in Yemen and then formulate the essential list of process requirements and recommendations for attaining economic sustainability development in the construction industry. The methodology used is based on the subsequent and previously conducted investigations:

- Data collection
- Survey on the local industry
- Policy selection and
- Delphi method for ranking and evaluating the policies

Data Collection

Literature and data collection was performed to build the necessary background on the country's national economic and cultural situation.The broad data collected and reviewed has revealed that there are macroeconomic problems in unemployment, inflation and external debts. All associated with a shortage of information and a lack of infrastructure [Sultan & Kajewski, 2003a&b].

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- In the context of the decision-making process, the establishment of adequate and appropriate information and statistics is considered to be the basis for sustainable success and development.
- The Yemen construction industry should put more effort into minimizing resource wastage occurring within the execution of construction projects, decisions should be based upon competent and well-organized planning to prevent selection the low quality projects, and so minimize maintenance and life cycle costs with these associated projects.
- Efforts should be concentrated on the quality production and use of local low energy materials. The government and the private sector should study and initiate more research on the use of local materials and the recommended measures for their development. As the modern construction industry will be relying on imported materials for some considerable time to come, the local industry should best adopt practices that utilize renewable resources and materials with low embodied energy.
- Establishing a standardized market system in order to allow market mechanisms to play a fundamental role in resource allocation.
- Engineers must acquire the skills, knowledge, and information on sustainable development. The promotion of sustainable development demands that engineers cultivate an

understanding of the economical, social and environmental issues, risks and impacts on the community.

IMPLICATIONS FOR FURTHER RESEARCH

Discussions with experts have elicited a variety of views to further investigate the following policies and issues:

- Investigate the best process for the government to change institutional and legal systems to enhance sustainable development.
- Investigate to wether the government should sustain and support small business enterprises and local firms for economic development or rather promote larger local firms.
- Will affordability be a major issue in sustainable economic activities?
- Investigate the effect of lean construction methodologies.
- Establishing methods to effect public perception towards sustainable development.
- Investigate policies aimed at the overall maximization of domestic employment to reduce poverty
- Policies aimed at encouraging foreign and local investors intervention in infrastructure projects
- Future policies and strategies on urbanisation.
- Policies aimed at integrating and improving the informal sector

The fact is that Yemen will not be able to integrate the newer sustainable technologies into low-income communities for a long time. However, Yemen has a long tradition of construction that is more sustainable and better suited to local conditions than that introduced by imported technologies. Therefore, another key area for research is to identify these construction practices and materials and develop them further to provide an improved standard of living, while providing low-income communities with the opportunity to create livable and inhabitable settlements while sustaining their cultural heritage.

CONCLUSION

Investigation into the construction industry of Yemen has shown that the attainment of economic sustainability within the existing local institutional, technical and economical difficulties needed the establishment of integrated policies, at the same time, for the successful implementation of these policies; there are needs for interrelated requirements and recommendations within this development process. This paper has suggested these process requirements and actions based on the current local conditions and on the policy rankings and discussions with experts.

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A Governance-lead approach to performance improvement

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Abstract

This paper reports on a research project that applies the latest global governance standards and business principles to local conditions in sub-Saharan Africa to improve performance in the built environment sector for sustainable national development.

The wider objective of the research is to develop a governance framework that can be applied to built environment sectors in developed and developing countries as a common framework of understanding aimed at improving decision making for sustainable development. The project included a search of global literature to establish the links between governance, sustainable development and the built environment sector. A draft governance framework has been developed and is being tested for conditions in developed and developing countries.

The wider project has proven that:

- Governance is a core component of the sustainable development agenda and is relevant to micro and macro stakeholders of the built environment
- A Governance framework provides the basis of a common decision making framework for sustainable development with global application.

In collaboration with local practitioners and, in the context of Ghana's national development policy, the governance framework was validated for use in Ghana as an example of a developing country. This approach has already had a significant impact on bringing Ghanaian built environment policy makers and practitioners together in a national workshop, developing an action plan aimed at improving the performance of the sector and defining the role of the sector in achieving sustainable national development and poverty reduction.

Keywords
Governance, decision-making, framework, sustainable development, application

A GOVERNANCE-LEAD APPROACH TO PERFORMANCE IMPROVEMENT

Introduction

This paper provides a brief introduction and report on the main conclusions of a research project aimed at developing a governance framework for sustainable development in the built environment sector. The paper reports also on the outcomes of a local initiative that aimed to validate the global findings for local conditions in Ghana, located in sub-Saharan Africa, and an example of a developing country.

Background and objectives of the research project

This research project started with an idea that, in the context of achieving sustainable development in the built environment sector, a new approach was needed. There was a need to provide practitioners with a structure or framework in which they could include environmental, social and economic parameters in their decision making. Specifically, delegates representing built environment policy makers and practitioners at the World Summit for Sustainable Development [GABS, 2002] had identified the need for a 'common framework of understanding' to enhance their ability to make better and more sustainable development choices. The author had previously explored the need for a 'framework of understanding' [Gilham, 2000] that would improve decision making for sustainable development and subsequent research [UNU, 2002] has shown an even wider demand for such a framework. It has been well established that decision making for sustainable development requires a wider understanding of issues, stakeholder requirements and stakeholder priorities. Extending both temporal and spatial boundaries, decision making for sustainable development requires decision makers to step outside of their areas of expertise and understanding and hence the demand for 'common frameworks' in which the steps to be taken and the rules to be applied are transparent and common to all participants.

The challenge therefore, that inspired the wider research project, was how to develop a common framework for understanding that would enhance the ability of decision makers throughout the built environment sector to embrace sustainable development issues in their policies and implementation practices.

The main outputs will be a Governance Framework for sustainable development in the built environment sector, validated for use in developed and developing countries using established standards and practices. Special attention would be placed on the case of the developing country, where practitioners would be engaged in a practical demonstration of a governance-lead approach to performance improvement.

Findings of the research project

Through a systematic exploration and analysis of literature linking governance, sustainable development and the built environment sector, critical conclusions have been drawn:

Governance, considered part of the political sciences and differentiated from Government, as a system for decision making and social order has, through demands for globalization and sustainable development, emerged as a topic in its own right. Mainstreamed through a process of policy formulation, research and practice, governance has emerged as two agendas, ie:

- Global governance – dealing with the relationships between and behaviour of governmental, intergovernmental, non-governmental and private sector organisations; and
- Corporate governance – dealing with the relationships between and behaviour of companies, their Directors and critical stakeholders.

Agenda 21 [UNSD 1992 and 2002] set out a comprehensive programme of measures for sustainable development including institutional reform and capacity building that aimed to create the 'social organisation' originally identified by Brundtland [WCED 1987] as a limitation on achieving sustainable development. It is through the gradual implementation of the sustainable development agenda [UN (2000), (2001) and WSSD (2002)] that both: Global governance - seeking to reform and build capacity at intergovernmental and national levels; and Corporate governance - seeking an extension of the corporate governance framework to include social, environmental and economic factors, have merged to become The essential enabler for sustainable development.

However, whilst governance lies at the heart of sustainable development and whilst sustainable development is a critical and well established area of research and knowledge development for the built environment sector, governance and other socio-cultural issues have largely remained unexplored. In the sector, the need for new decision-making tools has been evident since Vanegas et al (1996) showed us in Bourdeau et al (1998), that sustainable development in the built environment sector extended decision making from predominantly project-based time, cost and quality considerations, to first of all, include the wider impacts of resource consumption, emissions and biodiversity and subsequently include wider ranging issues such as social equity, economic constraints and environmental quality. Thus decision making for sustainable development extended traditional spatial and temporal boundaries and, when analysed from a governance perspective, challenged stakeholder sovereignty, institutional capacity, established systems and hierarchies as well as exposing core values of stakeholder groups to comparative scrutiny.

The research has shown that a new Governance Framework is required to provide built environment stakeholders with a framework for the comparative analysis and understanding necessary to achieve sustainable development. Analysis [Gilham 2004] has shown that a governance framework for both global and corporate environments comprises four key components:

1. A shared vision or purpose statement [GoG (1999) and CACG (1999)]
2. Key stakeholders including directors and policy makers [OECD (2004), Adei and Gilham (2003), CACG (1999), IIA/KPMG (2003)]
3. Key drivers – ie Legal, regulatory, fiscal requirements, 'market-forces' and voluntary standards [GoG (1999), Iskander and Chamlou (1999), OECD (2004)]
4. Capacity of organisations and governance structures [IIA/KPMG (2003), Adei and Gilham (2003), Iskander and Chamlou (1999)]

Within these components internal and external features come together in different ways to create a range of governance requirements that reflect specific market structures, traditions, regulations and cultural and societal values. Once determined, the main function of a governance framework is to inform the development of all corporate (governmental and non-governmental) strategies ensuring that effective measures are taken to satisfy the standards required of it. A governance framework is a strategic management tool for organizational leaders and policy makers enabling them to develop an effective governance strategy and, as indicated by King (2002) a balance between conformance with governance principles and their corporate objectives.

Local validation of global principles

It was recognized at an early stage in the investigations that governance standards and practices had generally emerged from developed country perspectives and practices. For example, Corporate governance emerged from the industrial revolution [Bondzi-Simpson, 1998] and Global governance had emerged from a global programme of institutional capacity building and public sector reform promoted by intergovernmental bodies such as the United Nations Development Programme [UNDP, 1999]. In fact, international monetary institutions such as the World Bank had increasingly applied governmental reform to the conditions for loans to national governments. This was a particular concern on behalf of developing countries [Woods and Narliker, 2001). Therefore, if the framework was to be truly 'common' with global application, special consideration was needed for validation in developing countries.

The remainder of this paper describes the validation process in Ghana as an example of a developing country in sub-Saharan Africa.

The national context - Ghana

The importance of an effective and efficient public sector for governance and national development is highlighted by the Ghana Poverty Reduction Strategy [GPRS, 2003] which is also Ghana's sustainable development strategy. The National Governance Programme [GoG, 2004a] also indicates the centrality of governance to national development and the recent creation of a Ministry for Public Sector Reform [GoG, 2004b] reinforces the centrality of governance to Ghana's national development policy..

Sustainable development, however, is not just dependent on matters enacted by government alone. The role of the private sector and civil society also requires good governance to ensure that resources are used effectively and efficiently. In the private sector there are initiatives like the Commonwealth Association for Corporate Governance, working with local organisations like Ghana's Institute of Management and Public Administration (GIMPA) to improve the governance performance of Ghanaian corporations. Efforts to increase transparency and openness in Ghana's civil society are marked by several changes including increasing media activity, engagement of civil society organisations in decision making and monitoring of governmental performance. In fact the recent peaceful democratic elections reinforce the dramatic progress being made in Ghana.

The Architects Registration Council - Ghana, with generous support and collaboration from other organisations, has held a series of events to bring these issues to the attention of built environment policy makers and practitioners. Each event has been planned to provide a platform on which knowledge could be transferred and in which policy makers and practitioners could engage in a process of learning for the future on:

1998 - Migration and Urbanisation – Effects on the planned city
2000 – Visions of the City: Accra in the 21st Century
2003 – Development Control and Sustainable Urban Planning

In preparations for the National Workshop planned as part of the local validation process, it was recognized by local built environment practitioners that by taking a governance-lead approach based on determining the governance framework for the sector, previous learning could be built upon and opportunities for successful reform and performance improvement could be identified.

The title for the National Workshop was agreed as: Governance and National Development: The role of the Built Environment Sector in Ghana.

The National Workshop

It was in support of Ghana's national development that the National Workshop was planned as a practical demonstration of commitment by an influential industry sector. The aim of all concerned was to improve the quality of national development in Ghana.

Put simply, there was a need to operationalise the principles of:

- Policy integration for sustainable development
- Good governance and accountability in public and private sectors
- Partnerships between public and private sector
- Increasing public and private sector investment for national development
- Sectoral and inter-sectoral initiatives for change

A culmination of over 12 months planning and effort by the organizers, the workshop attracted over 100 policy makers and practitioners from Ghana's built environment sector. The wide ranging and high level commitment from national and local government, professional bodies and the private sector; pays tribute to the timeliness and appropriateness of the Workshop's theme to Ghana's national development plans and the contribution of the built environment. This was confirmed by the Minister of Parliamentary Affairs when he said: '*The relevance of the theme at this time of our national development cannot be over-emphasised*.' Indeed, the enthusiasm and engagement of the participants demonstrated that governance and national development was a serious matter for practitioners as well as policy makers

The aims of the workshop were to develop:

- A vision statement for the built environment - developed and agreed by built environment policy makers and practitioners
- A governance framework for the built environment sector in Ghana - in which policy makers and practitioners can work together for effective national development
- A plan of action for the built environment sector as a whole and each of the four stakeholder groups - to make the necessary improvements and practical changes to existing policies and practice
- A consortium of policy makers and practitioners - who will take the agenda and action plan forward in Ghana

The Workshop was structured to capture the needs and experiences of policy makers and practitioners. Plenary sessions included presentations from senior representatives throughout the sector including government ministers, national experts in governance and professional practice. Detailed focus group sessions were held to capture the needs and practical experiences of four key stakeholder groups:

- National Government and their agencies
- Local Government
- Professional Bodies
- The Private Sector

Each group, under the guidance of a Chairperson and rapporteur:

- Explored the key governance issues affecting performance of their stakeholder group and the sector as a whole
- Explored the roles, relationships and responsibilities associated with different stakeholder groups
- Proposed actions for their own stakeholder group as well as contributing suggestions for a sector wide vision and plan of action

The workshop concluded in the presentation of a Communiqué which set out collective views of participants including a vision, objectives and proposed actions for the built environment sector in Ghana.

Analysis of Data and Outputs from the Workshop

There were two sources of data collected at the Workshop: Speakers papers; and Outputs from focus group sessions. The first source of data was a collection of 11 papers submitted and presented by speakers. Qualitative analysis techniques were used in which papers were read and re-read, key themes were identified, listed and grouped together using simple charting techniques. This structured approach to analyzing the qualitative data resulted in a comprehensive statement elaborating on key governance issues for the built environment sector in Ghana. The contents were (numbering refers to chapter numbers in the Workshop output publication):

4.1.1 The importance of Governance for National Development
4.1.2 The importance of the built environment sector for national development
4.1.3 Key Governance Issues for the built environment sector
 4.1.3.1 Strategic planning and sector effectiveness
 4.1.3.2 Internal governance and efficiency throughout the sector
 4.1.3.3 Land use
 4.1.3.4 Market conditions
4.1.4 Attitudes and potential barriers to change

Emerging also, through the structured analysis of speakers papers was a definition of Ghana's governance framework, fitting closely into the 4 previously identified components as follows (numbering refers to chapter numbers in the Workshop output publication):

4.2.1 A Vision or Purpose
4.2.2 Stakeholders
 4.2.2.1 Government
 4.2.2.2 Local Government (Metropolitan and District Assemblies)
 4.2.2.3 Professional Bodies and their members
 4.2.2.4 The built environment's private sector
4.2.3 Rules, regulations and standards
4.2.4 Capacity

This was an early indication that the governance framework developed from global principles was appropriate for the conditions in Ghana.

The second form of data collected at the Workshop was raw qualitative data emerging from the focus group sessions. This was brought together in the focus group sessions to include visions for each stakeholder group, descriptions of key roles and responsibilities and recommendations for action. The following extracts have been singled out as providing a snapshot of the very useful information describing the functionality and future governance requirements of built environment stakeholders.

The primary purpose of Government:

- Develop policies and Programmes to guide the development of the built environment in both urban and rural areas.
- To set up structures and agencies to implement the policies and programme
- To develop and enforce rules and regulations governing the development of the built environment
- Create an enabling environment with all stakeholders for development in the built environment
- Effective land administration (LAP)

The primary purpose of Local Government:

- Engage people in communities to participate in development decision making through:
  - Encouraging community based organisations to participate more fully in local governance eg (Watchdog committees)
  - Ensuring better integration of social groups in planning
- Ensure overall improvement of the built environment by:
  - More pro-active cooperation with professional bodies
  - Privatising their functions
  - Reviewing and redefining laws, processes and systems (such as Building regulations, revenue collection)
  - Preparing physical planning schemes and facilitate the production of base maps

The primary purpose of Professional Bodies:

- Bridge between regulations and clients
- Help harness the aspirations of client and investors
- Ensure satisfaction with stakeholder relationships
- Enforce existing professional standards
- Prepare for the future by
  - Modernizing professional ethics
  - Train young professionals
- Improve transparency
- Continue training of existing professionals
- Contribute to the formation of national policy for the built environment

The primary purpose of the private sector:

- To provide services/goals using efficient professional practices to ensure that clients get best value for investment within the environment of transparency, accountability and participation.
- Foster relationships with other stakeholders including Research institutions and land owners
- Implement improvements in health, safety and working conditions on site

From these extracts general conclusions have been drawn on the future governance needs of built environment stakeholders in Ghana. They include:

- Greater demands for governing effectively with existing systems and standards
- A more pro-active approach to improvements
- Improved co-ordination, stakeholder engagement and partnership for policy formulation, regulation and implementation

CONCLUSIONS

This research project has taken globally defined Governance standards and applied them to local conditions in the built environment sector of a developing country. It has employed a consultative and detailed analytical approach to collect data that enables an accurate assessment of the key governance issues affecting the local built environment sector and their wider applicability. Thus leading to the following conclusions:

- A governance-lead approach, using a governance framework consisting of four components (Vision, Stakeholders, Drivers, Capacity), provides a useful common framework on which built environment stakeholders can explore critical performance issues.
- The approach is based on the principle that all organisations have a governance framework in which they have to satisfy governance obligations. Whilst their individual vision, stakeholders, drivers and capacity are likely to differ, organisations will need to consider each of these components as part of their strategy planning and operations and a governance–lead approach provides an opportunity in which different stakeholder groups can explore common problems and common solutions.
- In this case, the focus has been on national development in Ghana and the role of the different stakeholders throughout the sector. Using the structure provided by the governance framework, workshop speakers and participants have presented a substantial body of evidence that describes the key performance related issues for each stakeholder group within the sector and the sector as a whole.
- Underpinned by the global research and practical application by the author in other organisations and sectors within Ghana, evidence suggests that the methodology can be applied in other developing countries as well as developed countries. A full application methodology and guidance is currently being developed by the author for future publication.

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Opportunities, Risks and Decision Making on Sino-Foreign Construction Joint Venture Projects: A Fuzzy AHP Approach

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Abstract
With the rapid economic development and the entry into the World Trade Organization (WTO), the Chinese construction industry has been widely opened to overseas contractors and investment entities as great opportunities with a common cooperation form of joint ventures (JVs). Extensive research and practice shows that JV activities are good opportunities that can bring potential benefits but at the same time may generate many risks. While a great deal of literature has studied these risks and presented constructive advices for managing individual risks, the methodologies used to analyze the risks were mainly qualitative and limited attempts have been made in pursuit of a quantitative method to assess the risk impacts on JV projects. This paper firstly sets up a hierarchy structure of risks associated with Sino-foreign construction JVs and then develops a fuzzy analytical hierarchy process (AHP) model for the appraisal of the risk environment pertaining to the JVs, in an aim to support the rational decision making of project stakeholders. An empirical case study is also used to demonstrate the application of the model. It is concluded that the fuzzy AHP is effective in tackling the risks involved in JV projects. The information presented in this paper should be interested to all parties considering JV business opportunities in China and the fuzzy AHP methods presented should be applicable to the analysis of risks associated with any types of construction projects.

Keywords
Risks, opportunities, decision making, construction, Sino-foreign joint venture, fuzzy analytical hierarchy process

INTRODUCTION

Since the early 1980s, China's "open door" policy has continuously attracted overseas investment and today makes her the second largest recipient of foreign direct investment in the world (Chadee and Qiu, 2001). The construction industry is one of the major areas absorbing overseas investment and the proportion of investment is still rapidly increasing (Luo *et al.*, 2001). The most common form of cooperation has been through joint ventures (JVs) between the Chinese and overseas parties (Luo, 2001; Shen *et al.*, 2001). Sino-foreign construction JVs can provide opportunities for the foreign parties to expand their business to the Chinese market which may indicate large and continuous benefits and also reduce potential risks in an unfamiliar market (Norwood and

Mansfield, 1999). From the Chinese perspective, JVs can not only attract foreign investment but also bring advanced technologies and management expertise.

Entering the new millennium, the construction industry is gaining impetus from a new surge of activities under the Chinese government policy to stimulate domestic demand to keep the continuous and stable increase of national economy (Bajaj and Zhang, 2003). Hence, a range of housing and infrastructure development projects are expected in the coming years. The development of these projects needs financial and technical support of overseas entities, which leads to new opportunities for Sino-foreign JVs. However, due to different political, social and economic systems, as well as different historical and cultural background, both the Chinese parties and their overseas counterparts are likely to encounter many risks in the implementation of JVs (Li *et al.*, 1999; Wang *et al.*, 1999; Shen *et al.*, 2001; Fang *et al.*, 2004; Gale and Luo, 2004). Research also shows that more than 50 percent of JVs ended with failures, particularly in developing countries (Beamish, 1993), which projects the importance for implementing risk management in forming and operating JVs.

While many studies have examined these risks from a quantitative manner and presented constructive advices for managing individual risks, few attempts have been made in pursuit of a quantitative method to assess the risk impacts on JV projects and evaluate the project viability holistically. This paper firstly sets up a hierarchy structure of risks associated with Sino-foreign construction JVs and then develops a fuzzy analytical hierarchy process (AHP) model for the appraisal of the risk environment pertaining to the JVs, in an aim to support the rational decision making of project stakeholders. An empirical case study is also used to demonstrate the application of the model. The information presented should appeal to all parties involved in a JV project, including the Chinese and overseas companies considering seizing the joint venture business opportunities in China.

RELATED PAST RESEARCH

Joint venture may be defined as "the commercial agreement between two or more companies in order to allow greater ease of work and cooperation towards achieving a common aim, through the manipulation of the appropriate resources (Norwood and Mansfield, 1999)". The enormous demand for housing and infrastructure ensures opportunities for both domestic and foreign parties in the Chinese construction market.

Since 1980s, the Chinese construction market has gradually been open to overseas companies. However, establishing wholly foreign owned construction firms used to be prohibited in China (Gale and Luo, 2004). So, foreign contractors had to set up construction JV companies to acquire the business. After China's entry into the WTO on 11 December 2001, the Chinese government promised to extend the privileges of overseas contractors in the construction field through three steps: (1) at first, foreign enterprises are not permitted to establish their branch organization in China to contract for projects directly; (2) within the three years immediately after China's accession to the WTO, foreign enterprises will be allowed step by step to establish solely foreign-owned enterprises but can only contract for limited types of projects; and (3) with five years of China's entry, solely foreign-owned businesses will be allowed gradually to contract all types of projects (Fang *et al.*, 2004). Although these policies potentially expand the market for foreign contractors, Sino-foreign JVs are still the most preferred form of cooperation used in practice (Chan and Suen, 2005), which might be due to unique benefits as mentioned previously.

Li *et al*. (1999) classified the risks associated with international construction JVs into three groups: internal, project-specific and external. The internal risks refer to those that are unique in a JV and are developed from the nature of the operation that causes conflicts within the JV organization. The project-specific risks refer to unexpected developments during the construction period that lead to time and cost overruns or in shortfalls in performance parameters of the completed project. The external risks represent the risks that derive from the competitive macro environment that the JV operates. They examined 25 potential risks with the aid of questionnaire surveys and identified the top five risks in international JVs in East Asian countries: client's cash flow problems, financial problems in partner's parent company, inconsistency in government policies, laws and regulations, economy fluctuation, and poor relationship. They also proposed that a foreign construction firm in an overseas JV practice could reduce its risks if it would carefully select its local partner, ensure that a good JV agreement is drafted, choose the right staff and subcontractors, establish good project relationships, and secure a fair construction contract with its client.

Shen *et al.* (2001) extracted a list of 58 risk factors associated with Sino-foreign construction JVs from literature and categorized them into six groups, namely financial, legal, management, market, policy and technical related. Then, they conducted surveys to examine these risks in the Chinese construction market and established a risk significance index to identify the most significant risks. The top three ranked risks include "cost increase due to changes of policies", "improper project feasibility study" and "project delay" and the top ten risks consist of five related to management, two related to market, two related to policy and one related to technical issue. They also analyzed the highly ranked and typical risks and proposed practical risk management strategies such as improving cooperation with government agencies, employing contracts to manage risks properly and controlling technical risks.

From the perspectives of Chinese contractors, Fang *et al.* (2004) investigated risks encountered by the local contractors while contracting for projects in the Chinese construction market. In comparison to Li *et al*'s research (1999), Fang *et al.* (2004) divided the risks into two categories: external risks and internal risks. They also used a risk importance index to evaluate the risk importance based on surveys and found that the main risks currently encountered by Chinese contractors in domestic markets include owner's irregular behavior, government departments' interference in construction markets, certain external environmental factors, subcontractors' incompetence and the poor quality of suppliers' goods. These research results provide valuable information for foreign contractors to gain a better understanding of the potential risks in the Chinese construction market.

Gale and Luo (2004) carried out a full population survey of 160 Sino-foreign JV based construction companies in four China's provinces to investigate key factors for the success of JVs at the formation stage. They identified a consensus agreement between the Chinese and foreign contractors on five factors leading to JV success at the formation stage, including "selection of suitable partners", "obtaining enough information about potential partners before negotiation", "clear statement of JV agreement", "clear identification of partners' objectives", and "control of the majority ownership of the capital". They concluded that the different perceptions associated with JV success held by Chinese and foreign partners may not exist at the JV formation stage although essentially there are different perceptions between local partners in developing countries and western partners about criteria associated with the JV success.

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The above efforts have examined the risks and risk management issues in Sino-foreign JVs. Although Li et al.'s research focused on the construction JV market in East Asia, the findings can contribute to the risk management practice in Sino-foreign JVs. Key risks were highlighted and appropriate strategies were proposed to tackle these risks in the JV practices. It appears that little attempt has been undertaken to give a quantitative assessment on the comprehensive level of all risks associated with a Sino-foreign JV, which might be more of concern to most foreign contractors expecting to enter the Chinese construction market with a reasonable level of risks.

Based on the findings of literature reviews, this present research aims to provide a generic quantitative method to assess the comprehensive level of risks coming along with any individual JV to evaluate whether JV is really viable for the delivery of the project. As different projects tend to expose different risks and different risks have different level of impact on the success of JVs, fuzzy Analytical Hierarchy Process method is one of the most optimal techniques to evaluate the risks associated with JVs and provide comprehensive information to project partners to make rational decision-making.

THE PROPOSED FUZZY AHP RISK ASSESSMENT APPROACH

Resembling human reasoning in its use of approximate information and uncertainty to generate decisions, fuzzy set theory is specifically designed to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many problems. The AHP is one of the extensively used multi-criteria decision-making methods for dealing with complex decision problems in which factors are categorized into different groups and levels and then prioritized or weighted accurately and consistently. At the formation stage, most risks associated with a JV are unclear to the project partners and the judgment of these risks is normally vague and imprecise. The Chinese and overseas partners need to make a comprehensive assessment with respect to the risky condition pertaining to the proposed Sino-foreign JV. The fuzzy Analytical Hierarchy Process approach will be employed to tackle the multi-faceted risk assessment involved in the decision making of the JV. The fuzzy AHP approach includes three steps: setting up the hierarchy structure of risks, determining the weight vector by AHP, and fuzzy assessment of risks, as presented below.

The hierarchy structure of risks

Based on a thorough literature review, a list of risks associated with Sino-foreign JVs can be identified and then classified where Li et al.'s (1999), Shen et al.'s (2001) and Fang et al.'s (2004) methods can be referred. To produce a generic hierarchy structure, the risks can be sorted into l groups at the criteria level, with a few risks at the attribute level under each group. Please note that more levels can be incorporated into the hierarchy structure in which the principle of the AHP approach is the same.

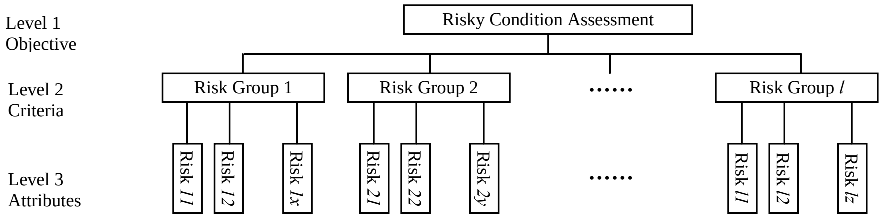

Fig. 1 Hierarchy Structure of Risk Factors

Determination of weight vector ω by AHP

AHP is used for scaling the weights of the elements in each level of the hierarchy with respect to the elements of the next higher level. This is done by means of pairwise comparisons of the activities to indicate the strength with which one activity dominates another vis-à-vis the criterion under which they are compared. The reason lies in that the performance of a system is a result of the interaction of various factors but every factor plays its own role and makes contribution to the system as a whole.

As per Saaty (1980), the pairwise comparison is established using a nine-point scale which converts the human preferences between available alternatives as equal importance, weak importance, strong importance, very strong importance and absolute importance, as shown in Table 1. The comparison is based on expert judgement. Suppose *m* experts are invited. Each expert's opinion is obtained and analyzed individually to determine the weight vector ω_i pertaining to Risk Group *i* *(i=1~l)*. The following procedures provide the method to obtain the relative weight of risk factors at Level 3 under Risk Group 1.

Table 1. Linguistic Measures of Importance (Saaty, 1980)

Scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance	There is evidence favouring one activity over another but it is not conclusive
5	Strong importance	Good evidence and logical criteria exists to show one is more important
7	Very strong importance	Conclusive evidence as to the importance of one activity over another
9	Absolute importance	The evidence in favour of one activity over another is of the highest possible form of affirmation
2,4,6,8	Intermediate values between adjacent scale values	When compromise is needed

As shown in Figure 1, Risk Group 1 include *x* number of risk factors, which is defined by:

$$\mu = \{\mu_1 \quad \mu_2 \quad \cdots \quad \mu_x\} \tag{1}$$

According to AHP, the pairwise judgement matrix for the relative weight of risk factors based on the k^{th} expert's opinion *(k = 1~m)* is an *x-by-x* non-zero reciprocal matrix, as presented below:

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$$P = \begin{bmatrix} 1 & p_{12} & \cdots & p_{1x} \\ 1/p_{12} & 1 & \cdots & p_{2x} \\ \vdots & \vdots & \ddots & \vdots \\ 1/p_{1x} & 1/p_{2x} & \cdots & 1 \end{bmatrix}$$
(2)

Where, *x is* the number of risk factors under risk group 1 and p_{ij} is the scale value of the pair of factors μ_i and μ_j *(i, j = 1~x)*, which is normally assigned to a 1 – 9 scale as per Table 1. Based on the root method (Saaty, 1980), the eigenvector is given by

$$\omega_{1k}' = \left(\omega'_{1k1} \quad \omega'_{1k2} \quad \cdots \quad \omega'_{1kx}\right)$$
(3)

$$\omega'_{1ki} = \sqrt[x]{\prod_{j=1}^{x} p_{ij}}$$
(4)

Then, the eigenvector needs to be normalized by:

$$\omega_{1ki} = \frac{\omega'_{1ki}}{\sum_{j=1}^{x} \omega'_{1kj}}$$
(5)

Based on the opinion of Expert *k*, the weight vector ω_{1k} of the risk factors under Risk Group 1 is determined.

$$\omega_{1k} = \left(\omega_{1k1} \quad \omega_{1k2} \quad \cdots \quad \omega_{1kx}\right)$$
(6)

Finally, in order to avoid artificial errors and the contradiction of different factors, a consistence check needs to be conducted until a satisfactory condition is obtained. A consistency check is a unique advantage of AHP to other methods. The maximum eigenvalue $\lambda_{\max}$ is a measure of consistency of judgement. This can be conducted by the following equation.

$$\lambda_{\max} = \frac{1}{x} \sum_{i=1}^{x} \frac{\left(P\omega_{1k}\right)}{\omega_{1ki}}$$
(7)

$$CR = \frac{CI}{RI} = \frac{1}{RI}\left(\frac{\lambda_{\max} - x}{x-1}\right)$$
(8)

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Where, *CR* denotes the consistency ratio; *CI* denotes the consistency index; *RI* denotes the average random consistency index, as shown in Table 2; *x* is the order of the judgement matrix. When *CR* < 0.1, the matrix has satisfactory consistency; otherwise, it should be adjusted.

Table 2. Average Random Consistency Index

x	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

After all *m* experts' opinions are analyzed and the weight vector ω_{1k} *(k=1~m)* based on each expert's judgement are worked out, the weight vector ω_1 for risk group 1 is determined by:

$$\omega_1 = \frac{1}{m}\sum_{k=1}^{m}\omega_{1k} = \begin{pmatrix} \frac{\sum_{k=1}^{m}\omega_{1k1}}{m} & \frac{\sum_{k=1}^{m}\omega_{1k2}}{m} & \cdots & \frac{\sum_{k=1}^{m}\omega_{1kx}}{m} \end{pmatrix} \tag{9}$$

It should be noted that the invited experts may have different level of knowledge of the risks associated with JVs and hence their opinions may have different level of impacts on the pairwise comparison. A weight coefficient reflecting the expert difference can be incorporated in the above equation. However, this issue is not considered in this paper to simplify the research.

Likewise, the weight vectors ($\omega_2 \sim \omega_l$) for risk factors at Level 3 under Risk Group *2~l* can be obtained by means of the above described method. And the weight vectors ω_G for the risk groups at Level 2 under the general objective can also be determined with this method.

Fuzzy evaluation matrix

Grounded on a thorough understanding of the characteristics of the proposed Sino-foreign JV project, the same or another group of experts may be invited to comment on the performance of each risk factor within the project. Again, assume that the objective being evaluated is the risk factors at Level 3 under Risk Group 1 and the set is defined as $\mu = \{\mu_1 \quad \mu_2 \quad \cdots \quad \mu_x\}$. The appraisal set is the possible evaluation grading result, as defined by

$$V = \{v_1 \quad v_2 \quad \cdots \quad v_n\} \tag{10}$$

Herein, the grades are linguistic measures of the performance of each risk factor, such as *good*, *poor*, *high* and *low*; *n* is the number of the grades. The appraisal of risk factor *i* under Risk Group 1 as per the appraisal set is defined as an appraisal vector:

$$R_{1i} = (r_{1i1} \quad r_{1i2} \quad \cdots \quad r_{1in}) \tag{11}$$

$$r_{1ih} = \frac{N_{1ih}}{m} \tag{12}$$

Where, r_{1ih} *(h =1~n)* is the fuzzy membership degree of appraisal of the factor *i* under Risk Group 1 to the grade *h*; N_{1ih} is the frequency of appraisal grading result v_h for factor *i; m* is the number of experts. The above description can be regarded as a fuzzy subset of *V*:

$$f : \mu \to f(V); \quad \mu_i| \to \begin{pmatrix} r_{1i1} & r_{1i2} & \cdots & r_{1in} \end{pmatrix}$$
(13)

The fuzzy appraisal matrix R_1 of all *x* factors is

$$R_1 = \begin{bmatrix} R_{11} \\ R_{12} \\ \vdots \\ R_{1x} \end{bmatrix} = \begin{bmatrix} r_{111} & r_{112} & \cdots & r_{11n} \\ r_{121} & r_{122} & \cdots & r_{12n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{1x1} & r_{1x2} & \cdots & r_{1xn} \end{bmatrix}$$
(14)

The fuzzy appraisal matrixes *(R_2 ~ R_l)* of risk factors under Risk Group *2 ~ l* can be obtained using the same method, which will not be further explained here.

Fuzzy AHP evaluation

To explore the level of risky condition in a JV, a comprehensive evaluation can be made by multiplying Eq. (9) and (14) using an appropriate fuzzy arithmetic operator σ. In order to consider the collaborative impacts of all risks and at the same time keep the information of individual risk, a fuzzy arithmetic operator $\sigma = (\bullet, \oplus)$ is chosen. At Level 3, the appraisal of risk factors under Risk Group 1 can be calculated in the following appraisal vector B_1:

$$B_1 = \omega_1 \sigma R_1 = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1n} \end{pmatrix}$$
(15)

where, $b_{1j} = 1 \wedge \sum_{i=1}^{x} \omega_{1i} r_{1ij}$ as per Eq. (9) and (14). The appraisal vectors of risk factors under all risk groups comprise the appraisal matrix R_G at Level 2, as presented by:

$$R_G = \begin{bmatrix} B_1 \\ B_2 \\ \vdots \\ B_l \end{bmatrix} = \begin{bmatrix} \omega_1 \sigma R_1 \\ \omega_2 \sigma R_2 \\ \vdots \\ \omega_l \sigma R_l \end{bmatrix}$$
(16)

Where, B_i is the appraisal vector of risk factors under risk group *i*.

The final fuzzy evaluation vector *B* of the risk performance in the JV practice is made by multiplying the weight vector ω_G and the appraisal vector R_G of risk groups, as shown by:

$$B = \omega_G \sigma R_G = \begin{pmatrix} b_1 & b_2 & \cdots & b_l \end{pmatrix}$$
(17)

According to the maximum subordination law, the comprehensive level of risky condition associated with the project can be decided by

$$b_{\max} = b_1 \vee b_2 \vee \cdots \vee b_l = \max\{b_1 \quad b_2 \quad \cdots \quad b_l\}$$
(18)

CASE STUDY – APPLICATION OF FUZZY AHP APPROACH TO A SINO-FOREIGN JV PROJECT

A freeway JV construction project in Hebei, P.R. China is presented as an empirical case study to illustrate the applicability of the fuzzy AHP approach developed. The People’s Government of Hebei is the project client and one Chinese contractor and one overseas contractor comprised the Sino-foreign JV parties. Based on experiences and preliminary research with respect to the risks associated with JVs in Chinese construction market, the foreign contractor identified a list of 20 risks and categorized them into three groups: internal, project specific and external risks, as shown in Figure 2.

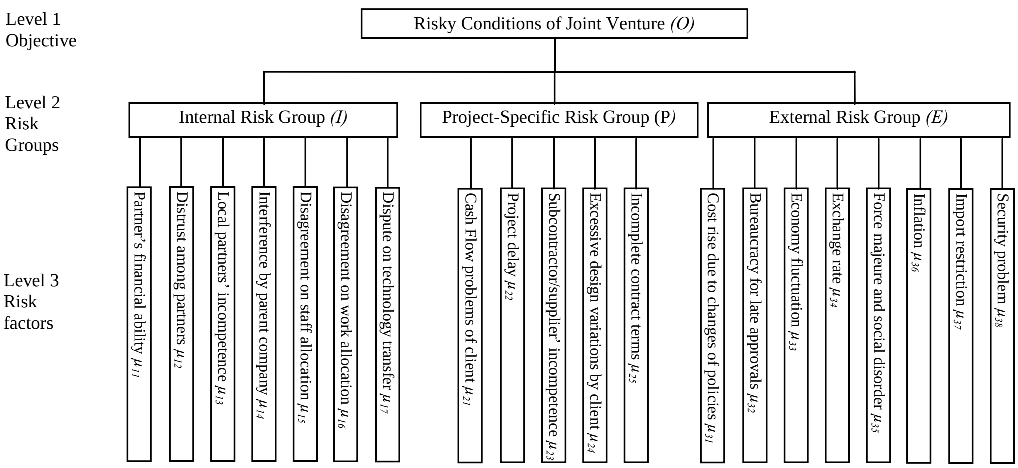

Fig. 2 Hierarchy of risks associated with a Sino-foreign JV freeway project

In the structure, the risky condition assessment *(O)* at Level 1 is the objective; internal *(I)*, project-specific *(P)* and external *(E)* risk groups at Level 2 are three criteria for the risky condition assessment; risk factors (μ_{11}~ μ_{38}) at Level 3 are attributes under the three risk groups. The two levels of risk membership sets are defined, namely with the objective level: $O = \{I, P, E\}$ and the risk group level: $I = \{\mu_{11}, \mu_{12}, \cdots, \mu_{17}\}$, $P = \{\mu_{21}, \mu_{22}, \cdots, \mu_{25}\}$ and $E = \{\mu_{31}, \mu_{32}, \cdots, \mu_{38}\}$.

Five domestic and overseas experts with robust knowledge and experience of Sino-foreign JVs and freeway construction are invited to carry out the pairwise comparison of the importance of risk factors at Level 3 and risk groups at Level 2. By means of Eq. (1) ~ (6), the feedbacks are collated and analyzed to obtain the weight vector of each expert’ judgment matrix, as shown in Table 3. The maximum eigenvalue $\lambda_{\max}$ and consistency index *(CI)* and ratio (CR) pertaining to each expert’s judgment matrix are calculated as well using Eq. (7) and (8). It is evident that all values of CR are less than 0.1. Therefore, it can be concluded that a reasonable level of consistency has been achieved by using expert judgment. Then, the average weight vectors of risk factors at Level 3 and risk groups at Level 2 are determined.

Table 3. Weight Vectors of Risk Factors and Risk Groups

Risks /risk groups	Experts	Weight vector (Weight coefficient of risks/risk groups)	Maximum eigenvalue (λ_{max})	CI	CR
Internal Risks	Exp. 1	ω_{11} = (0.296, 0.177, 0.146, 0.117, 0.106, 0.096, 0.061)	7.33	0.054	0.041
	Exp. 2	ω_{12} = (0.313, 0.174, 0.143, 0.115, 0.105, 0.091, 0.058)	7.31	0.051	0.039
	Exp. 3	ω_{13} = (0.124, 0.219, 0.187, 0.137, 0.145, 0.119, 0.068)	7.56	0.094	0.071
	Exp. 4	ω_{14} = (0.392, 0.105, 0.098, 0.133, 0.121, 0.095, 0.056)	7.44	0.074	0.056
	Exp. 5	ω_{15} = (0.314, 0.254, 0.078, 0.118, 0.107, 0.079, 0.049)	7.50	0.083	0.063
	Average	**ω_1 = (0.288, 0.186, 0.130, 0.124, 0.117, 0.096, 0.059)**			
Project-Specific Risks	Exp. 1	ω_{21} = (0.375, 0.210, 0.159, 0.128, 0.128)	5.06	0.015	0.013
	Exp. 2	ω_{22} = (0.419, 0.215, 0.150, 0.121, 0.094)	5.18	0.045	0.040
	Exp. 3	ω_{23} = (0.188, 0.463, 0.108, 0.077, 0.164)	5.11	0.029	0.026
	Exp. 4	ω_{24} = (0.236, 0.287, 0.165, 0.205, 0.106)	5.29	0.073	0.065
	Exp. 5	ω_{25} = (0.134, 0.449, 0.106, 0.267, 0.044)	5.21	0.053	0.048
	Average	**ω_2 = (0.270, 0.325, 0.138, 0.160, 0.107)**			
External Risks	Exp. 1	ω_{31} = (0.290, 0.167, 0.140, 0.111, 0.101, 0.093, 0.053, 0.045)	8.13	0.018	0.013
	Exp. 2	ω_{32} = (0.282, 0.213, 0.124, 0.103, 0.091, 0.103, 0.043, 0.041)	8.24	0.034	0.024
	Exp. 3	ω_{33} = (0.204, 0.343, 0.148, 0.073, 0.082, 0.072, 0.041, 0.038)	8.30	0.042	0.030
	Exp. 4	ω_{34} = (0.181, 0.386, 0.086, 0.088, 0.083, 0.074, 0.043, 0.058)	8.48	0.069	0.049
	Exp. 5	ω_{35} = (0.180, 0.096, 0.088, 0.084, 0.062, 0.096, 0.356, 0.037)	8.60	0.086	0.061
	Average	**ω_3 = (0.228, 0.241, 0.117, 0.092, 0.084, 0.088, 0.107, 0.044)**			
Risk Groups	Exp. 1	ω_{G1} = (0.540, 0.297, 0.163)	3.01	0.005	0.008
	Exp. 2	ω_{G2} = (0.297, 0.240, 0.163)	3.01	0.005	0.008
	Exp. 3	ω_{G3} = (0.320, 0.558, 0.122)	3.02	0.009	0.016
	Exp. 4	ω_{G4} = (0.286, 0.143, 0.571)	3.00	0	0
	Exp. 5	ω_{G5} = (0.136, 0.625, 0.238)	3.02	0.009	0.016
	Average	**ω_G = (0.316, 0.433, 0.252)**			

Note: CI – the consistency index; CR – the consistency ratio.

Based on a thorough investigation of the JV parties and the proposed freeway construction projects, the above 5 experts and another 5 senior personnel from the foreign contractor company are invited to evaluate the performance of each risk factor within this Sino-foreign JV. The appraisal set of the performance includes 5 grades as $V = \{extremly\ severe, severe, medium, light, very\ light\}$. The feedbacks are analyzed and the results are presented in Table 4. By means of Eq. (10)~(14), the experts' judgment with respect to the performance of each risk factor is statistically fractioned to form the appraisal vector, and the vectors of all risk factors under a risk group comprise the appraisal matrix. Then, the appraisal vector of each risk group is obtained with the aid of Eq. (15) and the final fuzzy evaluation vector of the risky condition of the freeway JV is determined by Eq. (16) and (17), as shown by ***B = (0.189, 0.277, 0.226, 0.158, 0.150)*** at the bottom of Table 4.

According to the maximum subordination law, the comprehensive level value *(b_{max})* of risky condition associated with the Sino-foreign freeway construction JV equals to *0.277*, which indicates that the risky condition is at the ***severe*** level. If planning to proceed with the JV project, the foreign contractor needs to take appropriate risk management strategies to deal with the risks appropriately.

The key risks can be preliminarily identified as per the expert's judgment matrix in Table 4. For example, among the project-specific risks, the client's cash flow and project delay are regarded as the major risks influencing the success of the JV. The methods to manage these risks have been proposed by Li *et al.* (1999) and Shen *et al.* (2001).

Table 4. Fuzzy Evaluation of Risky Condition of the Freeway JV

Risks /risk groups	**Attributes**	**Weight coefficient**	**Appraisal Matrix/Vector**					
			(Very severe, Severe, Medium, Light, Very Light)					
Internal Risks	μ_{11}	0.288	R_{11} =	(0.3,	0.3,	0.1,	0.1,	0.2)
	μ_{12}	0.186	R_{12} =	(0.2,	0.2,	0.3,	0.2,	0.1)
	μ_{13}	0.130	R_{13} =	(0.3,	0.2,	0.3,	0.1,	0.1)
	μ_{14}	0.124	R_{14} =	(0.3,	0.1,	0.4,	0.1,	0.1)
	μ_{15}	0.117	R_{15} =	(0.1,	0.1,	0.4,	0.3,	0.1)
	μ_{16}	0.096	R_{16} =	(0.3,	0.3,	0.2,	0.1,	0.1)
	μ_{17}	0.059	R_{17} =	(0.2,	0.1,	0.3,	0.2,	0.2)
Appraisal Vector of Internal Risk Group *(I)*			B_1 **=**	**(0.252,**	**0.208,**	**0.257,**	**0.248,**	**0.135)**
Project-Specific Risks	μ_{21}	0.270	R_{21} =	(0.1,	0.6,	0.2,	0.1,	0.0)
	μ_{22}	0.325	R_{22} =	(0.2,	0.4,	0.2,	0.1,	0.1)
	μ_{23}	0.138	R_{23} =	(0.1,	0.2,	0.1,	0.4,	0.2)
	μ_{24}	0.160	R_{24} =	(0.2,	0.2,	0.1,	0.2,	0.3)
	μ_{25}	0.107	R_{25} =	(0.2,	0.1,	0.3,	0.1,	0.3)
Appraisal Vector of Project-Specific Risk Group *(P)*			B_2 **=**	**(0.159,**	**0.362,**	**0.181,**	**0.157,**	**0.140)**
External Risks	μ_{31}	0.228	R_{31} =	(0.1,	0.2,	0.2,	0.1,	0.4)
	μ_{32}	0.241	R_{32} =	(0.3,	0.2,	0.4,	0.1,	0.0)
	μ_{33}	0.117	R_{33} =	(0.1,	0.2,	0.2,	0.3,	0.2)
	μ_{34}	0.092	R_{34} =	(0.1,	0.3,	0.3,	0.2,	0.1)
	μ_{35}	0.084	R_{35} =	(0.2,	0.2,	0.2,	0.1,	0.3)
	μ_{36}	0.088	R_{36} =	(0.1,	0.4,	0.2,	0.2,	0.1)
	μ_{37}	0.107	R_{37} =	(0.1,	0.1,	0.3,	0.3,	0.2)
	μ_{38}	0.044	R_{38} =	(0.2,	0.2,	0.1,	0.3,	0.2)
Appraisal Vector of External Risk Group *(E)*			B_3 **=**	**(0.161,**	**0.216,**	**0.264,**	**0.172,**	**0.188)**
Risk Groups	*I*	0.316	B_1 =	(0.122,	0.180,	0.285,	0.267,	0.148)
	P	0.433	B_2 =	(0.198,	0.213,	0.262,	0.252,	0.076)
	E	0.252	B_3 =	(0.161,	0.216,	0.264,	0.172,	0.188)
Appraisal Vector of Risky Condition of the Freeway JV (O)			***B*** **=**	**(0.189,**	**0.277,**	**0.226,**	**0.158,**	**0.150)**

CONCLUSIONS

Under China's "open-door" policy and entering WTO, overseas contractors and developers are encouraged to enter the Chinese construction market in the form of JVs with local firms. While this brings unprecedented opportunities to overseas entities, enormous risks may arise due to different culture, social, political, economic and environmental background between the Chinese and foreign parties. In addition, diverse financial and technical risks also apply to different construction projects. Many previous studies have explored the risks from qualitative manners and proposed approaches to tackle these risks, which contributes a lot the practice of Sino-foreign JVs. However, there has been limited research dedicated to the quantitative assessment of the risky conditions/factors of JVs.

This paper has first reviewed the related literature and then developed a quantitative risks assessment model for Sino-foreign JV projects using Fuzzy Set theory and AHP technique. In this approach, the hierarchy structure of risks associated with a JV is established at first. Based on the expert's judgment, the weight coefficients of risk factors and risk groups are acquired with the aid of the AHP technique and the fuzzy evaluation matrixes of risk factors is founded through fuzzy set theory. Then, the aggregation of weight coefficients and fuzzy evaluation matrixes produces the appraisal vector of risky condition of the JV. Based on the maximum subordination law, the comprehensive level of risky condition can be determined, which provides judgmental information for a rational decision-making. At the end of the paper, an empirical case study on a Sino-foreign freeway construction JV project is provided to demonstrate the applicability of the Fuzzy AHP approach developed. It is concluded that while opportunities are great, the risks associated with the Sino-Foreign JV projects should be properly assessed and the proposed fuzzy AHP method is a suitable for such tasks. It should be pointed out that although this paper was written using Sino-foreign JV projects as an example, the fuzzy AHP approach presented should be equally useful to analyze and assess risks associated with any types of construction projects.

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Renovation and maintenance subsector in Spain

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Abstract
Although the renovation and maintenance subsector in the Western European context represents a strategically important construction subsector, in Spain its share in the total construction activity is significantly low. The aim of this paper is to review the historical evolution of this subsector and to provide short-term prospects for the upcoming years. Finally, from trends and drivers of change in the Spanish renovation and maintenance subsector, lessons and advices for countries with developing economies are suggested.

Keywords
Renovation and maintenance subsector, developing countries, Spain.

INTRODUCTION

Spain can become a point of reference for countries in developing economies as this country has undergone a fast political, economic and cultural evolution in recent years. In fact, the consolidation of Spain's industrial development did not occur until the 1950s. In this way, economic statistics are available with certain reliability and they allow the analysis of the Spanish experience.

After the developing process, construction sector in Spain has become one of the most important sectors (in terms of volume) of Spain's economy (in 2004, Spanish construction sector accounted for 9.7% of Gross Domestic Product) [National Statistics Institute (2005d)]. According to SEOPAN, the residential building construction accounted for 33% of total construction activity in 2004, representing the most important construction subsector in the Spanish context. Renovation and maintenance subsector accounted for 25%, followed closely by civil works subsector, which represented 24% of the construction activity. Non-residential building construction registered just 18% of the total Spanish construction activity [SEOPAN (2005)].

In contrast with this situation, activity distribution by subsectors in the West-European context indicates that renovation and maintenance is the first construction subsector in importance, accounting for 37% of the whole construction activity [SEOPAN (2005)]. If we exclude civil engineering, refurbishment sector is responsible for almost half (48%) of the output in the building market [Euroconstruct (2005b)].

Table 1: Construction activity by subsectors. Comparison between Spain and West-Europe (data from 2004). Source: SEOPAN, 2005.

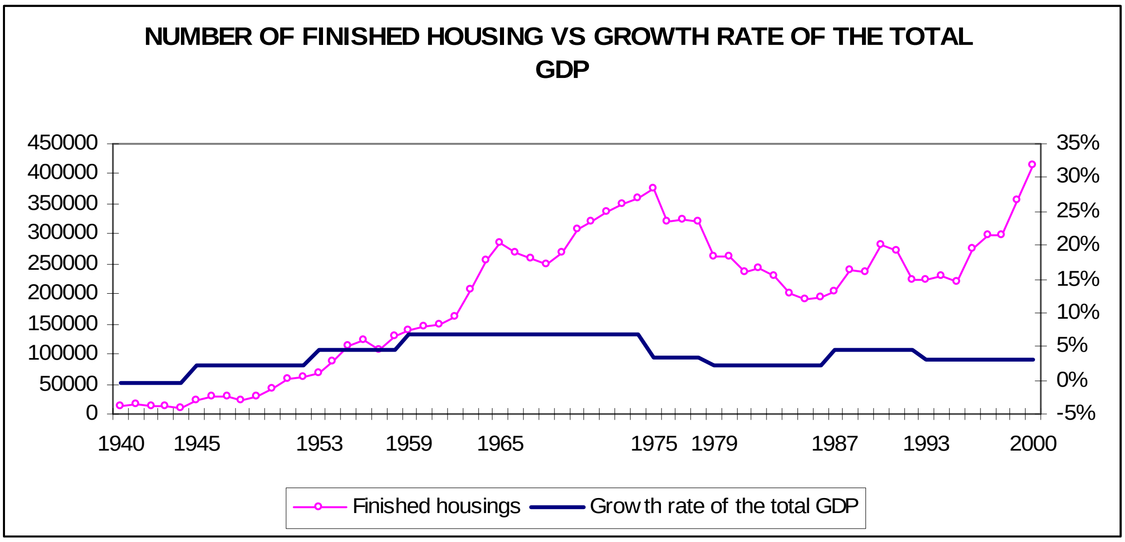
Subsector	Spain	West Europe
Residential building	33%	24%
Non-residential building	18%	17%
Civil works	24%	22%
Renovation and maintenance	25%	37%

In countries such as Germany, France, Italy and the United Kingdom, which underwent the economic development process earlier than Spain, the renovation is the subsector which generates the most value [Euroconstruct (2005b)].

It can be deduced that the contribution of the renovation and maintenance subsector in the whole construction activity is higher as more developed is the economy of the country. In fact, countries with developed economies include a large scale of inherited building stocks, most of them built during the economic expansion periods. Figure 1 illustrates the evolution of the number of housings according to its year of construction in Spain.

During the economic development process, especially during those phases with high growth, Spain registered a high increase in the number of built housings. This expansion process continued after 1964 (year of the economic consolidation of Spain according to the United Nations' economic standards), until the general crisis underwent in Spain from 1975 to 1985. As the construction evolution's pattern tends to follow the general economic cycle, from that point on there was a substantial recovery which took the number of finished housings in 2004 to 506,349 units [Ministry of Development (2005)].

Fig 1 Evolution of the number of housings by year of construction versus growth rate of the total GDP by economic cycles from 1940 to 2003. Source: Own elaboration with data from Prados de la Escosura, 2003, Tamames et al. 2000 and National Statistics Institute, 2005a.



HISTORICAL PRESPECTIVE OF THE REFURBISHMENT MARKET IN SPAIN

In general, specific statistical for the Spanish renovation and maintenance sector is only available after 1994. However, a ten year analysis gives some trends that must be studied.

Renovation and maintenance activity

Figure 2 shows the increase of the refurbishment sector in Spain and how it has taken relevance along the nineties. Therefore, the number of refurbishment and restoration licenses (number of projects carried out) has increased from approximately 9,750 in 1994 to 29,300 in 2004 [Ministry of Development (2005)]. This means that in ten years this kind of licences has been triplicated. On the other hand, the increase of the refurbishment licenses related to the total of the Spanish construction is also important. In 1994, only 12% of the whole licenses of the construction sector where for refurbishment and restoration, meanwhile in the year 2004 they represented the 18% [Ministry of Development (2005)].

The incidence of the refurbishment sector activity is also reflected in economical terms. In fact, the budget of refurbishment and restoration has increased by 400% in 10 years [Ministry of Development (2005)].

Refurbishment and restoration actions in Spain are basically carried out in housing as shown in the figure 4. In 2004, the 74 % of the whole refurbished and restored buildings in Spain were destined to housing. However, housing restoration only comprised the 50% of the total business volume in the refurbishment sector in general [Ministry of Development (2005)].

Fig 2 Refurbishment of buildings as part of the whole construction sector in terms of number of licenses in Spain. Source: Own elaboration with information from Ministry of Development, 2005.

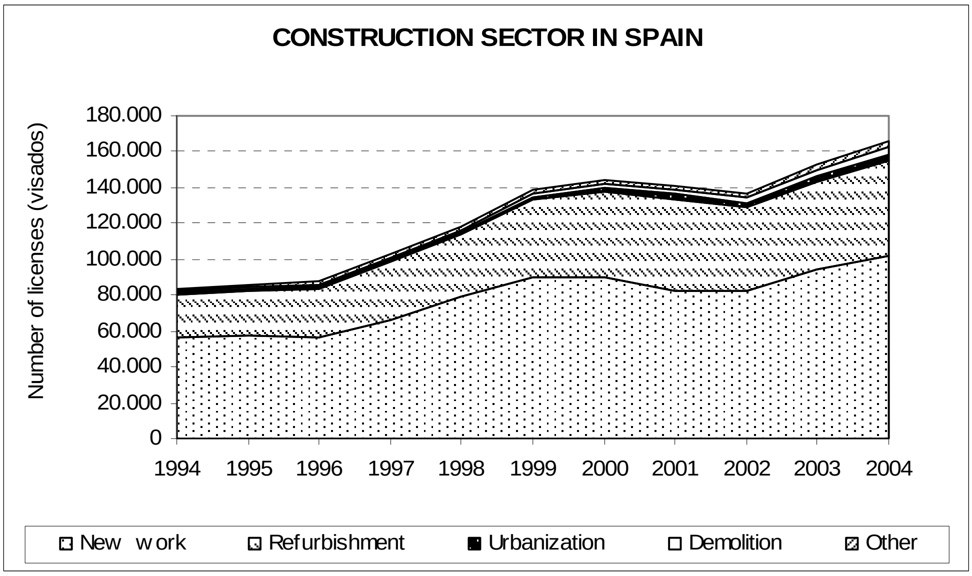
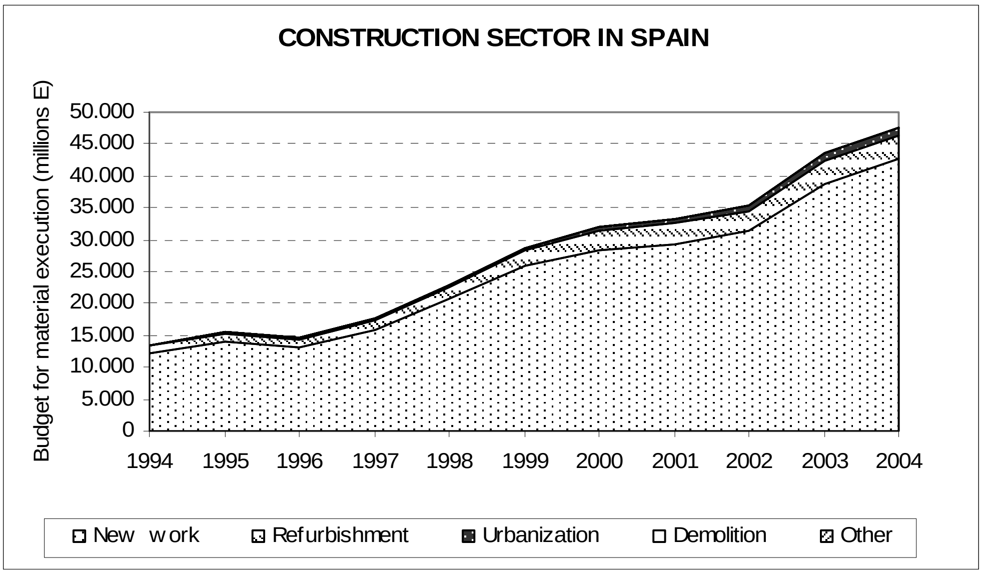
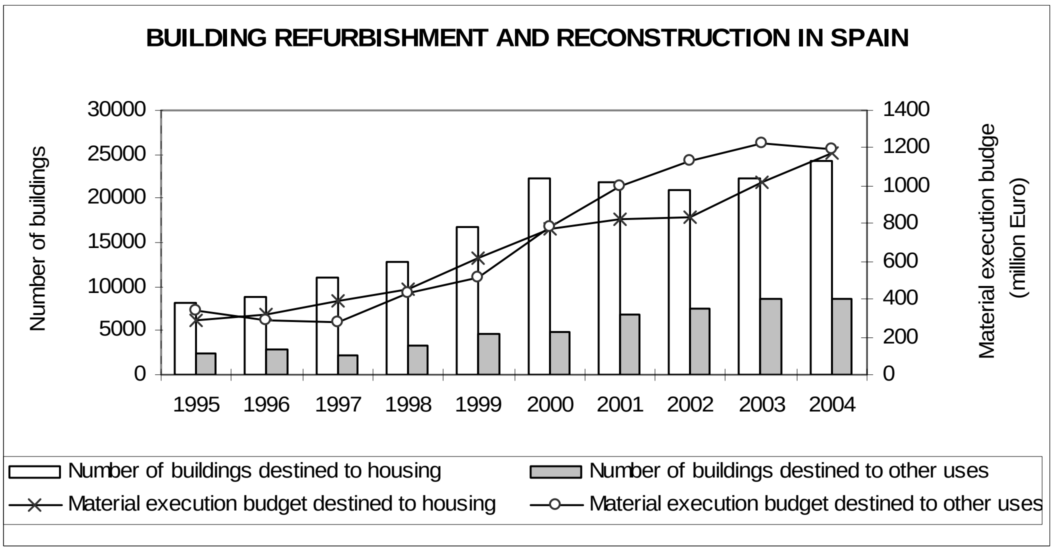


Fig 3 Refurbishment of buildings as part of the whole construction sector in terms of budget of material execution. Source: Own elaboration with information from Ministry of Development, 2005.



Licenses issued for the housing refurbishment and restoration have increased form approximately 14,000 in 1995 to 42,500 during the year 2004 [Ministry of Development (2005)]. This means that in 10 years the licenses issued of this building typology has increased by 300%. Moreover, in 1994 licenses related to housing refurbishment and restoration were the 4% of the whole housing licenses issued while in 2004 the number of licenses increased to 6% [Ministry of Development (2005)].

Fig 4 Distribution of the refurbishment and reconstruction of buildings according to its destination in Spain. Source: Own elaboration with information from Ministry of Development, 2005.



Business structure

There is no available data about the internal structure of the renovation market in Spain; however the renovation is a market where small and medium enterprises (SMEs) are doing particularly well. In the European context, Euroconstruct experts' estimate that around two thirds of all the value generated in the refurbishment sector was produced by SMEs, especially in partial renovations (only a functional part of the buildings is repaired or replaced) and particular renovations (operations mostly by private individuals that do not affect the entire building).

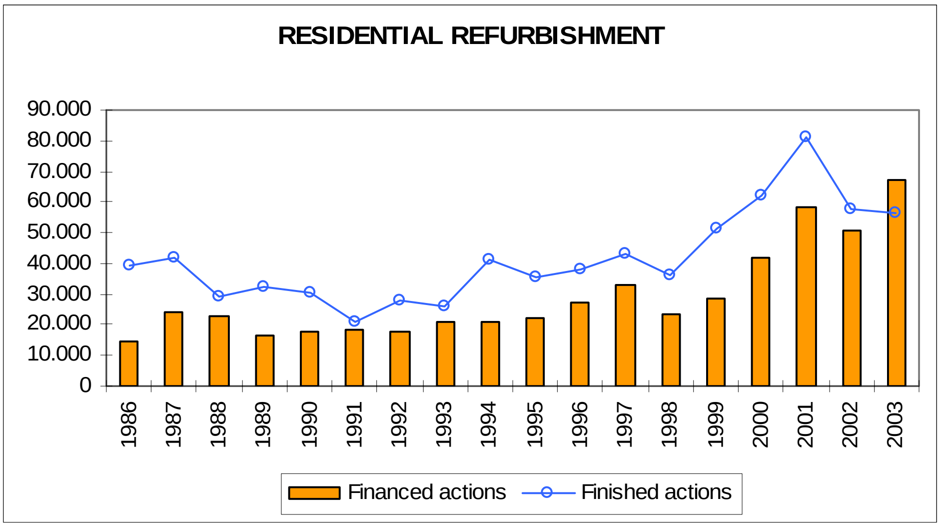
Euroconstruct experts' expect for 2005 that partial renovations will account for 33% of the market volume whereas particular renovations will account for 45-55%. Comprehensive renovations (complete buildings that are fully renovated) will account for 15-20% of the whole renovation market volume in 2005 [Euroconstruct (2005b)].

Promoting policies

From an institutional standpoint, recent Spanish Housing Plans have destined large economical resources to housing refurbishment programmes. According to data from National Statistics Institute, the number of financed actions for housing refurbishment was 39,192 in 1986, whereas in 2003 it increased to 56,703.

According to Euroconstruct experts, the greatest flows of public money are directed towards renovation on a medium scale –residents'associations that repair façades, roofs or installations– and particularly those whose aim is saving energy, improving accessibility or those carried out in areas of social priority.

Fig 5 Evolution of financed actions and finished actions in residential refurbishment in Spain. Source: Own elaboration with information from National Statistics Institute, 2005b.



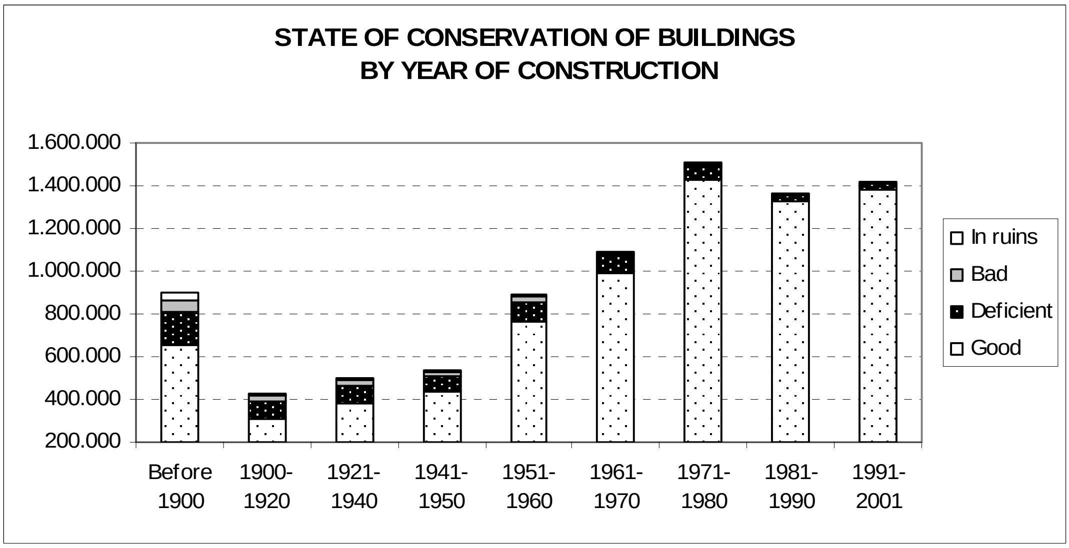
OPPORTUNITIES FOR THE SPANISH RENOVATION AND MAINTENANCE SUBSECTOR

Useful data to show the future scenario of the refurbishment and reconstruction subsector in Spain is from one hand the state of conservation of the buildings and from the other hand, the year when they were built.

With respect to the state of conservation of the buildings, it is important to underline that 94,794 buildings in Spain were found to be in ruins (data from 2001) [National Statistics Institute (2005c)]. This means that 1% of the Spanish buildings have an official declaration of ruin. In 2001, 2% of the Spanish buildings had noticeable cracks or bulgings in their facades, subsidence or lack of horizontality in floors or in ceilings, so the state of conservation of 173,891 buildings was bad [National Statistics Institute (2005c)]. According to the National Statistics Institute, 8% of buildings (681,636) were classified to have some deficiency in 2001, as they had their sewage system in bad conditions, there was dampness in walls or seepages in roofs. It is considered that 89 % (7,673,464) of the Spanish buildings were in good conditions in 2001.

In terms of the buildings' age, it is important to underline that 901,299 buildings (10.4%) were built before 1900. 426,872 buildings (4.95%) are currently older than 85 years, as they were built from 1900 to 1920 [National Statistics Institute (2005c)]. Moreover, 5.76% of the Spanish buildings (497,039) were built during the 1921-1940 period whereas 6.26% of the buildings (539,425) where built during the 1941-1950 period. According to National Statistics Institute, 886,544 Spanish buildings (10.28%) were built from 1951 to 1960 and more than one millions of buildings (1,090,319, 12.64%) were built from 1961 to 1970. The 1970s was the highest peak in construction (1,504,984 buildings were built, which represents 17.45%) although followed very closely by the last two decades: 1981-1990 (1,360,191, 15.77%) and 1991-2001 (1,417,202, 16.43%).

Fig 6 State of conservation of buildings destined mainly for dwellings by year of construction in 2001. Source: Own elaboration with information from National Statistics Institute, 2005c.



CONCLUSION

This paper has focused on the Spanish renovation and maintenance activity, its business structure and the existing promoting policies for the buildings' refurbishment. As stated before, Spain has not yet reached the economic development level of its European neighbours. Although the renovation and maintenance subsector in Spain has taken relevance along the nineties in terms of licenses as well as in economical terms, its share in the total construction activity (25%) is significantly lower compared with the share of this subsector in the whole EU-15 (37%). This fact is tightly linked to the countries' economic development process, as countries with consolidated economies include a large scale of inherited building stocks, most of them built during the economic expansion periods.

Current Spanish situation is likely to change in the near future as new housing subsector should experience a downturn in 2006 that should continue in 2007 [Euroconstruct (2005a)]. In periods of recession and weak growth, repair and maintenance work plays a countercyclical role in the building industry [Euroconstruct (2004)], so it is expected that the Spanish renovation and maintenance subsector will undergo a positive trend during the coming years. Anyway, refurbishment subsector includes an emergency component and therefore it is not as linked as new construction subsector to the general economic cycle.

On the other hand, public financing maintenance and renovation of buildings (which clearly stimulates the refurbishment subsector) has been an important issue in Spain during recent years and according to the last Spanish Housing Plan this trend is expected to continue growing.

Moreover, the characterization of the Spanish built environment reveals an important market for the renovation and maintenance subsector. Nowadays, more than 950,000 buildings (which represent the 11% of the Spanish buildings) are in a poor state (with some deficiency, in bad conditions or in ruins) so they are susceptible of being refurbished or restored. In addition, it has to be highlighted that nearly 2,400,000 buildings were built before the fifties, sometimes with serious flaws of quality. Therefore, around 27% of the buildings are currently older than 55 years and they are gradually increasing the potential market for the refurbishment sector.

At the same time, an ageing population also provides opportunities for the renovation and maintenance subsector. Senior citizens are expected to live longer than today in buildings mostly with a certain age, so they will gradually increase the need of improving homes.

In addition, it is largely and internationally acknowledged that the re-use of buildings can minimise the depletion of non-renewable resources. Therefore the renovation and maintenance subsector becomes essential to reach the goals for sustainable development, mainly from a whole life cycle assessment point of view.

In conclusion, the renovation and maintenance subsector has a greater relevance as more consolidated is the economy of a certain country, due to the age of the buildings. Also a development of sustainable strategies for the built environment and other local government policies such as the establishment of urban refurbishment programmes can turn the renovation and maintenance subsector into a flourishing segment in countries with both developed and developing countries during the coming years.

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The role of the construction sector in the Spanish economy. Historical perspective and extrapolation to countries with developing economies.

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Abstract
The aim of this paper is to review the Spanish economic development process undergone during the last century, with especial attention to the role of the construction sector in the Spanish economy since the 1960s. The paper is organised in three main parts. The first one deals with the transformation of the Spanish economic structure from a sectorial perspective during the last century and analyses the role played by the construction sector in terms of economic activity, employment and business structure. In the second section, short-term prospects in housing, non-residential and civil engineering construction are provided. Finally, the last section suggests lessons and advices for developing countries as the impact of the construction upon the Spanish economy during the last century is supposed to be moved to these countries.

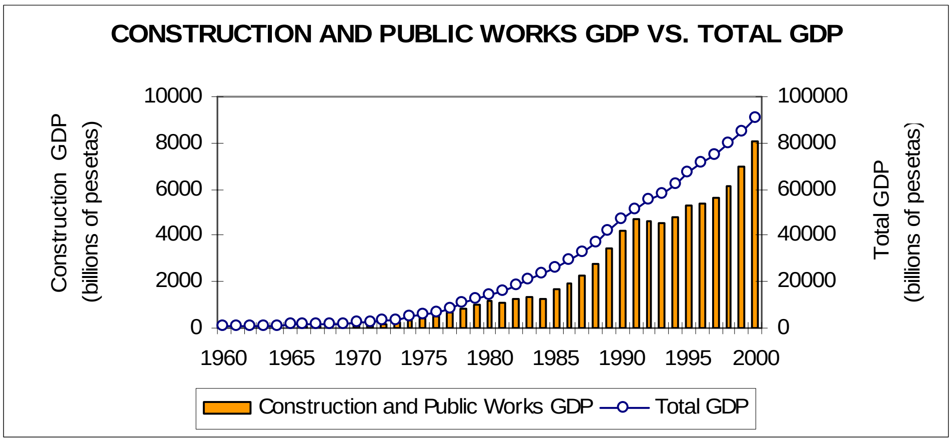
Keywords
Construction activity, construction employment, business structure, developing countries, Spain.

INTRODUCTION

Analyzing the transformation of the Spanish economic structure is particularly interesting for developing countries, as Spain has undergone a fast political, economic and cultural evolution in recent years. It has to be pointed that until very recently, a dearth of reliable statistical data on the Spanish economy [Harrison (2004)] made it well-nigh impossible to study and analyse the Spanish experience. Prados de la Escosura (2003) has published an extensive set of economic statistics, covering the period from 1850 to 2000. Therefore, historical data in this paper has been taken from this source whenever possible.

The consolidation of the Spanish industrial development did not occur until the second half of the twentieth century. As late as 1957, value-added in agriculture, forestry and fishing sector was higher than that of the manufacturing sector [Prados de la Escosura (2003)]. In addition, it should be noted that Spain was considered by United Nations' economic standards as a developing country until 1964. Nevertheless, from that point on, industrial and construction production together with service activities came to represent the base on which the dynamism of the Spanish economy was built and the agricultural sector no longer dominated the economic life of the country. Figure 1 shows the evolution of Spanish Gross Domestic Product (GDP) from 1960 to 2000.

Fig 1 Evolution of Spain's GDP at factor costs. Source: Own elaboration with data from Prados de la Escosura, 2003.



Nowadays, the structure of the Spanish economy is in accordance with that of a developed country, with the services sector being the main contributor to GDP followed by industry. These two sectors represent almost 75% of Spain's GDP (data from 2004) [National Statistics Institute (2005d)].

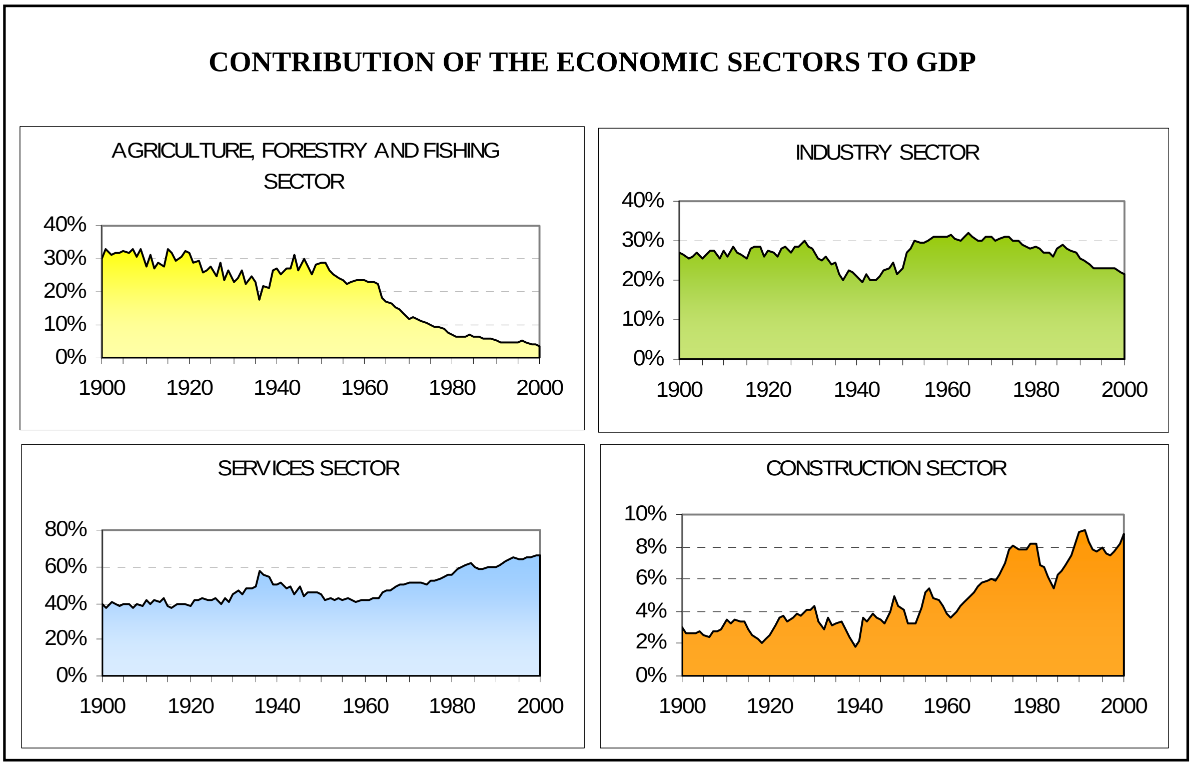
HISTORICAL PERSPECTIVE OF THE ECONOMIC TRANSFORMATION IN SPAIN

General framework

The structure of the GDP has changed over time as the Spanish economy has developed. During the twentieth century, the agriculture sector has seen its share in total GDP diminish drastically. The fall in the relative importance of agriculture was particularly intense from 1950 to 1975. In contrast, the industry sector expanded most rapidly between 1950 and 1975, with its share of GDP rising from 23% to 30% over the same period [Prados de la Escosura (2003)]. However, during the crisis period, between 1975 and 1985, this situation changed radically and the contribution of this sector to the dynamism of the Spanish economy underwent a drastic reduction. The trajectory of the services sector has partly thwarted the one of the industrial sector. During the crisis period, services sector was the only which achieved a growth rate above the average of the whole economy, and by 1985 its share in the economy had reached 59% of the total Spain's GDP [Prados de la Escosura (2003)]. Construction sector in Spain has undergone a significant growth during last century. Since 1955, the contribution of construction sector to the growth of the economy was generally above 4% whereas in year 2000 it reached 8.8% [Prados de la Escosura (2003)]. Moreover, since 2000 Spanish construction sector is still growing. According to data from National Statistics Institute, in 2004 construction sector accounted for 9.7% of GDP [National Statistics Institute (2005d)].

In general, trends in the economy have been moved to the employment rates. According to the figure 3, primary sector has experienced the most important fall in its contribution to the Spanish employment. Globally, the employment in the industry sector has followed the economic trend as well as in the services sector.

Fig 2 Evolution of the contribution of Agriculture, forestry and fishing, Industry, Services and Construction sectors to GDP. Source: Own elaboration with data from Prados de la Escosura , 2003.



According to Prados de la Escosura 2003, construction sector accounted for 6.6% of the total number of people employed in Spain in 1950, whereas in 1975 it accounted for 9.5%. During 1975-1985 period, employment in the construction sector underwent an important fell because of the economic crisis but afterwards there was a substantial recovery which took the construction sector to account for 10.7% of the employment (year 2000) [Prados de la Escosura (2003)]. Moreover, since 2000 construction employment in Spain is still growing. At the end of 2004, the construction sector employed 12.5% of the Spanish workers [National Statistics Institute, (2005c)].

Construction activity

Figure 4 shows the evolution pattern of the Spanish construction sector in terms of GDP compared with the trend described by the total GDP through the last four decades. It is clear that the construction evolution's pattern tends to follow, to a certain degree, the general economic cycle.

Construction employment

Obviously, the economic dynamism of the construction sector has moved to the job creation so during the last four decades, employment activity in the Spanish construction sector has been positive. Since 1995, the number of jobs in the construction sector has increased in 84% (year of reference: 2004). Only during 2004, construction sector created in Spain 150,000 new jobs. [National Statistics Institute (2005c)]. Moreover, construction sector is the one with the lowest unemployment rate (11.32% in 2004) in Spain, excluding primary sector [National Statistics Institute (2005c)].

Fig 3 Evolution of the contribution of Agriculture, forestry and fishing, Industry, Services and Construction sectors to employment during the last century in Spain. Source: Own elaboration with data from Prados de la Escosura, 2003.

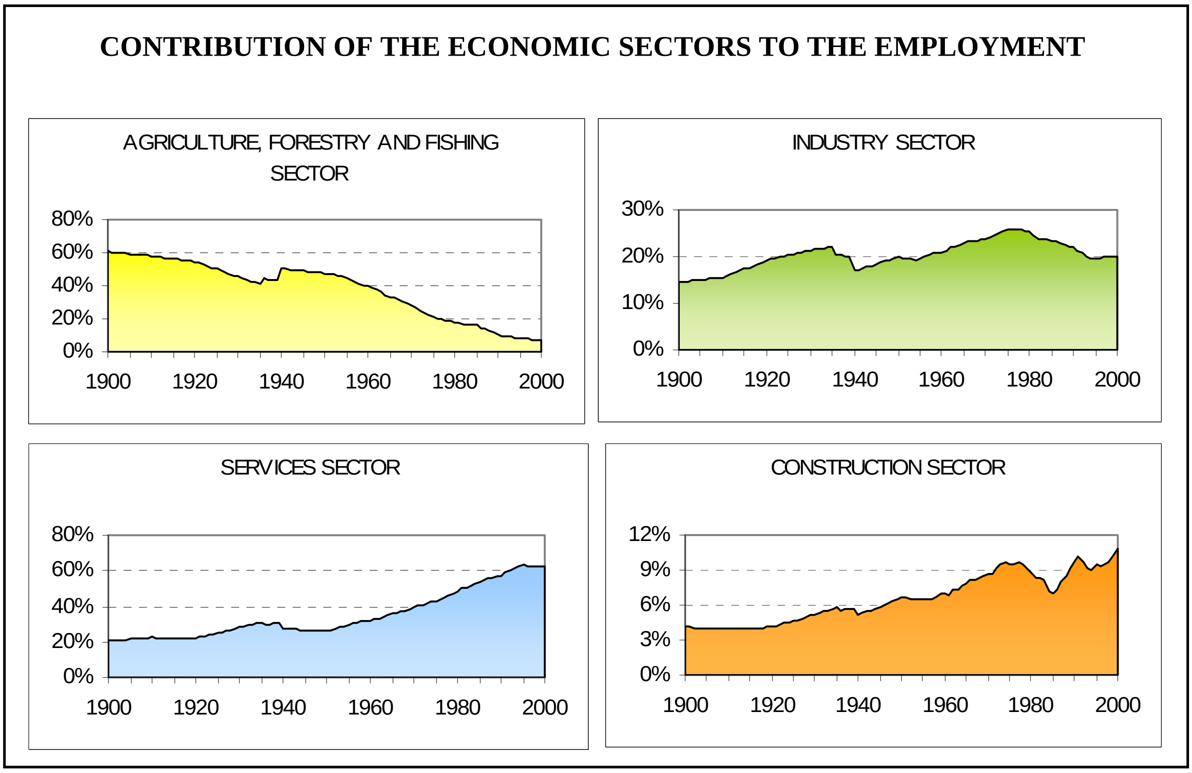
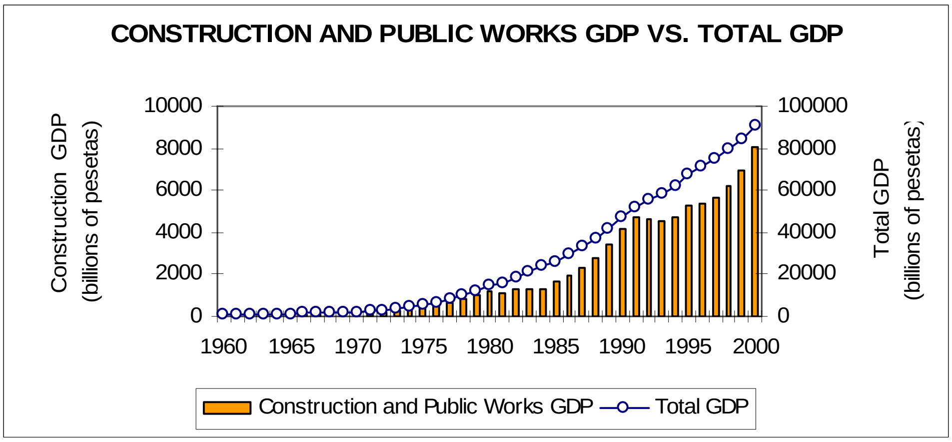


Fig 4 Evolution of the Construction and Public Works sector GDP versus total GDP from 1960 to 2000 in Spain. Source: Own elaboration with data from Prados de la Escosura, 2003.



In addition, the evolution of the construction sector's contribution rate in the Spanish employment has growth less than the contribution of the construction sector to the total GDP through recent years. As said before, the Spanish construction sector has experienced a meaningful extension process in recent years but according to the trend shown in figure 6 it has also experienced an increase of the relative labour productivity. Relative labour productivity of the construction and public works sector has been calculated as the ratio between the contribution to total GDP and the contribution to total employment in this sector [Prados de la Escosura (2003)].

Fig 5 Evolution of people employed from 1965 to 2000 in Spain. Source: Own elaboration with data from National Statistics Institute, 2005b and 2005c. As there was no available information related to employed people in construction sector from 1965 to 1971, data for this period correspond to working population.

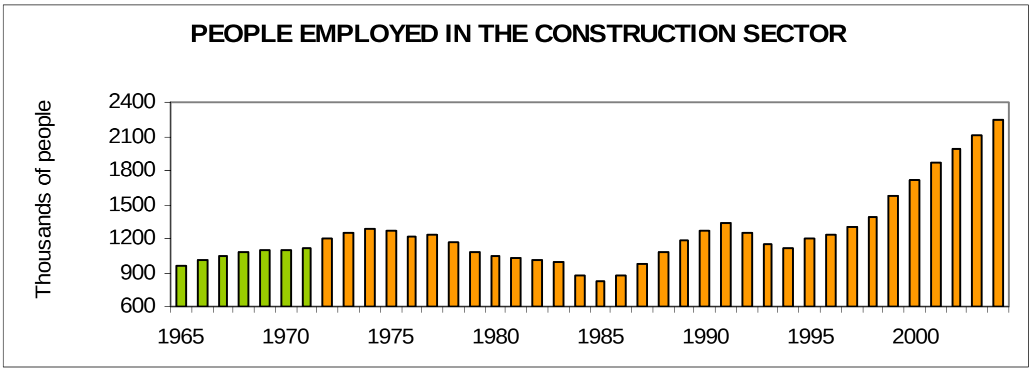
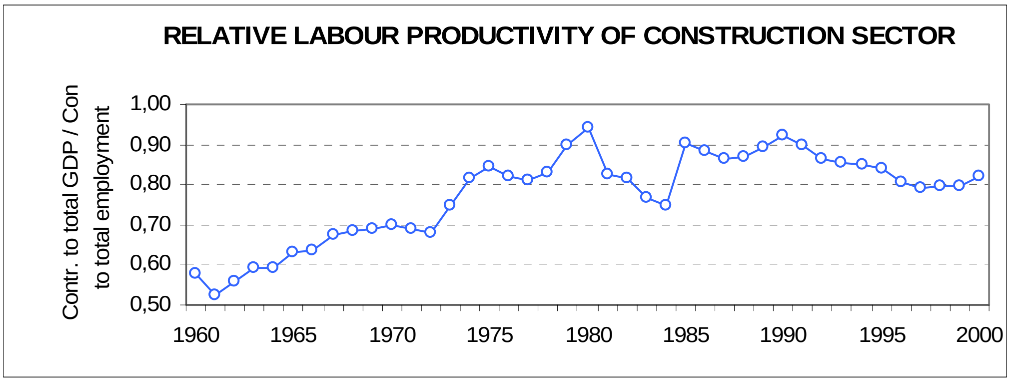
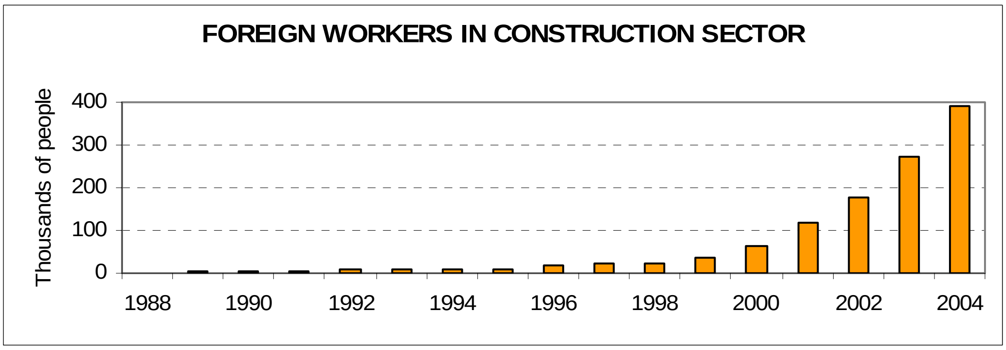


Fig 6 Evolution of the relative labour productivity (ratio between the contribution to total GDP and the contribution to total employment) in the Construction and Public Works sector from 1960 to 2000 in Spain. Source: Own elaboration with data from Prados de la Escosura, 2003



Another particular characteristic of the construction sector in Spain is its temporality. About 46.4% of employers have temporary contracts against a national sectors average of 25.6% (data from 2001) [National Statistics Institute (2005c)]. This high rate is due to the differences between projects, to changes in the geographic location of works and to the needs for different types of specialities during the construction execution.

Fig 7 Evolution of the number of foreign workers in the construction sector from 1988 to 2004 in Spain. Source: Own elaboration with data from National Statistics Institute, 2005c.

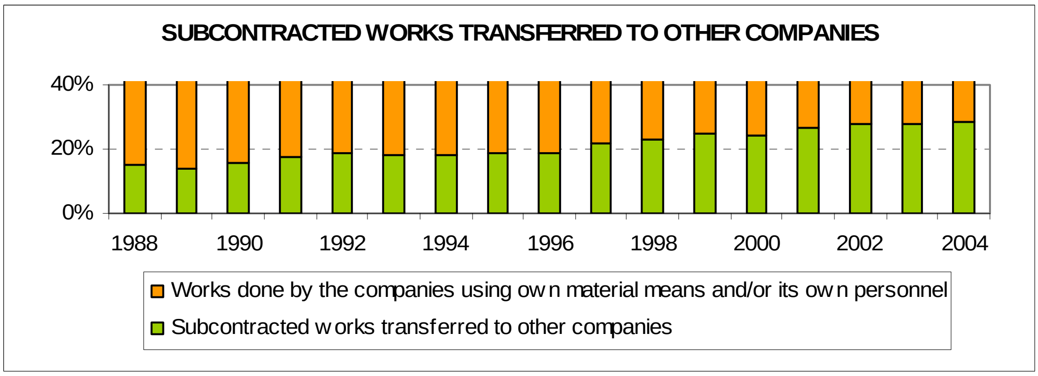


It should be noted that in recent years the number of foreign workers in the construction sector has undergone a significant increase. According to the Economically Active Population Survey from the National Statistics Institute, at the end of 2004, 426,800 foreigners were employed in the sector compared to 12,400 in 1996. At present, the percentage of foreign workers employed in the construction sector is about 23.5% [National Statistics Institute (2005c)]. Nowadays, a substantial proportion of the construction sector's workers comprise unskilled labourers, about 30.5% of them are illiterate or just have primary education (data from 2004) against 19.4% for the rest of sectors (mean value) [National Statistics Institute (2005c)].

Business structure

The business structure of the Spanish construction sector is characterised by the generalization of subcontracting. Big companies contract works directly but they do not execute them using own material means and/or their own personnel. The main contractor subcontracts the execution of a part of the works to other smaller companies, although he assumes the final responsibility. According to data from the Spanish Ministry of Development subcontracting represents about 28.5% (data from 2004) of the total works done by the construction companies.

Fig 8 Evolution of the subcontracted works transferred to other companies. Source: Own elaboration with information from Ministry of Development, 2005.



Therefore, the business structure of the Spanish construction sector is characterised by its fragmentation (big companies coexist with thousands of small companies and autonomous workers). In 2005, according to the Central Company Directory, the Spanish construction sector includes 58 large-sized companies whose staff has more than 1000 workers (only 6 of them have more than 5000 workers), being the total number of companies 415,585. Only 4% of the construction companies are medium-sized (from 20 to 999 workers) whereas 50% of the companies are small-sized (with less than 19 workers) and 46% are self-employed workers. [National Statistics Institute (2005a)].

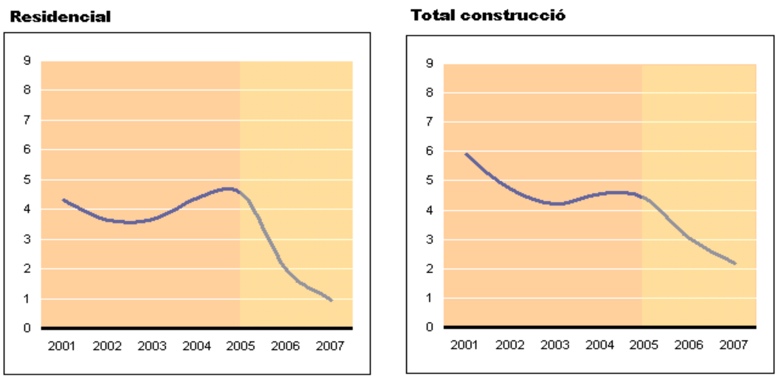
EXPECTED TRENDS OF THE CONSTRUCTION SECTOR IN THE SPANISH ECONOMY

According to forecasts done by Spanish and European experts, the Spanish construction market will grow at slower pace than it was used to. The general trend in all construction subsectors is towards a decline in the positive rate of activity growth of the past few years. New housing construction is expected to undergo the highest growth in 2005 (from 5.5% to 6.5%) [SEOPAN (2005)]. However, according to Euroconstruct 2005 report, new housing would experience a downturn in 2006 that would continue in 2007. On the other hand, civil engineering is expected to be the most dynamic subsector in Spain during the following years. Euroconstruct and SEOPAN analysts agree on an expected growth rate in civil engineering of 5-6% approximately for the 2005-2006 period. The demand for repair and maintenance work is expected to grow around 2.5% annual in Spain during the next years according to SEOPAN 2005 report. However, Euroconstruct report (June 2005) suggests a highest growth rate (4%). SEOPAN and Euroconstruct agree on adopting the hypothesis of a gradual slowdown in the non-residential construction activity. This subsector is expected to undergo the lowest growth rate (1.8%) in 2005 [Euroconstruct (2005)].

CONCLUSIONS

Spain can become a point of reference for countries in developing economies as this country has undergone a fast political, economic and cultural evolution in recent years. In fact, the consolidation of Spain's industrial development did not occur until the second half of the twentieth century. In this way, economic statistics are available with certain reliability and they allow the analysis of the Spanish experience.

Fig 9 Growth rate for construction sector in Spain. Interannual change (%) for 2001-2004 period and forecasts for 2005-2007 period. Source: Euroconstruct, 2005.



Construction sector behaviour during the Spanish economic development process has been analysed in this paper. It can be concluded that during the last century, Spanish construction sector has turned into a powerful driving force behind the Spain's economy. Construction economic activity has grown and its contribution to the GDP currently accounts for more than 9.5%. Obviously, the dynamism of the construction activity has motivated the creation of many jobs but not always under permanent contracts. The number of foreign workers in the construction sector has undergone a significant increase during recent years, most of them increasing the percentage of unskilled labourers in the sector. Although there has been a general increasing trend in the relative labour productivity from 1960 to 1980, from that point on it seems to have come to a standstill. Even later, since 1990, the relative labour productivity has decreased and this fact might be related with the increasing percentage of unskilled labourers in the sector. As a consequence of the heterogeneous business structure of the Spanish construction sector, a severe decline of the construction activity (although it is not yet forecast by the experts) could call into question thousands of small companies and autonomous workers. However, subcontracting works could probably minimize in a certain degree the expected consequences. As a result of this process, small-sized companies and self-employed workers could have to intensify its specialization.

Evolution of the Spanish construction sector offers some interesting trends that might be reproduced by countries in developing economies. Drawing lessons from the Spanish history can be useful to countries with developing economies, mainly if they focus not only on the Spanish successes but rather on its weaknesses.

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Construction Market in South-East and East Asia: Prospects and influencing factors

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Abstract
The construction market in South-East and East Asia is expected to grow massively as the countries prepare to improve their physical infrastructure to cope with their rapidly growing economies following their recovery from the effects of the 1997 Asian economic and financial crisis. At the same time, the construction industry in Singapore has faced a period of declining demand for the past eight years. Thus, in recent years, the construction enterprises in Singapore have been targeting the regional market.

This paper reports on part of a study which sought to identify the trends in prospects of the market in the region and the influencing factors, and to propose strategies Singapore firms could adopt to compete in the market. The part of the study covered in this paper was based on a review of the literature, and structured interviews of senior construction practitioners and administrators of the industry. It was found that whereas there will be increased opportunities, there will be stiff competition. Singapore construction firms will have to adopt a strategic approach to their operations in the area. The study proposes possible strategies they can adopt, and, thus, helps to enhance their competitiveness.

Keywords
Construction market, regional trends, causes, implications, suitable strategies

INTRODUCTION

Estimates of Levels of Activity

The engineering and construction (E&C) market in the South-East and East Asia region is expected to grow at a fast pace in the medium term. The countries are undertaking large volumes of major projects to improve their physical infrastructure to enable their economies to grow following the resumed influx of foreign direct investment into the region as the economies recover from the effects of the 1997 Asian economic and financial crisis. Bon and Crosthwaite (2000) found that Asia had the highest proportion of

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construction spending in GDP during 1996-98 of 14.5%, compared with a world average of 11%. It is pertinent to note that this was during the Asian financial and economic crisis when levels of construction activity were falling in most Southeast and East Asian countries. Mawhinney (2000) considers Southeast Asia as playing an important role as "a global competition zone" (p. 14) where, because of "future potential" (p. 14), many global players were already present.

A study by US-based Global Insight Inc., found that the 55 countries with the largest construction markets spent a total of US$3.9 trillion on construction in 2004; this figure was expected to exceed US$4.8 billion by 2008 [Tulacz, 2005]. The data show that China currently has the third largest construction market (after the US and Japan). In 2004, China spent US$269 billion on construction, and that this would rise to US$440 billion by 2008. India is in the 11th position in the world, spending US$74 billion in 2004, with a projection that this figure would increase to US$100 billion by 2008.

Of the two countries, China and India, much has been written on the prospects for construction in China [see, for example, Flanagan and Li (1997)]. The prospects in India, and in a few countries in Asia are now considered. India's national economy has grown strongly in the past decade, and is poised for further expansion. What is referred to as a problem of "deficit infrastructure deficit" (in power, telecommunications, ports, airports and railways) is becoming a bottleneck in the bid by the economy to expand [*The Hindu*, 2005]. The Prime Minister, Dr Manmohan Singh, who chairs the Infrastructure Committee himself, estimates that India would need to invest US$150 billion to improve its airports, railways, power, telecommunications, and other utilities. He also promised to spend US$40 billion by 2009 to improve upon irrigation, housing, water, electricity and roads to alleviate rural poverty (about 350 million of India's 1.1 billion people live on less than US$1 a day; and 70% live in villages) [Bloomberg.com, 2005]. Under the four-year Bharat Nirman (or "Building India") plan, the government aims to provide electricity to all 250 million rural homes; build 6 million houses; and provide safe drinking water to the 74,000 villages with no access to it. Each of the 700,000 villages in India will have at least one telephone [Bloomberg.com, 2005]. The government also has plans to give a face lift to the cities. This includes major urban renewal for 60 cities and "a unified infrastructure development scheme" for all other cities" [Edwin, 2005].

The Indian state has little room to finance such investment because it is obliged to reduce its budget by 0.3% of GDP a year until 2009 to erase its budget deficit. Much of these developments will be financed through public-private partnerships (PPP). The government has been putting in place the necessary regulatory framework; in February 2005, the Indian government fully opened up the construction sector by allowing up to 100% foreign investment in townships, housing, built-up infrastructure and construction development projects (housing, commercial premises, hotels, resorts, hospitals, educational institutions, recreational facilities, city and regional level infrastructure) [ENR.com, 2005].

Other countries in Asia are also growing strongly, and offer opportunities for international construction firms. For example, Pakistan seeks investment in infrastructure and energy to meet the requirements of its fast growing economy. Pakistan's economy is expected to grow by 8.4% in 2005 and 7% in 2006. Its exports will be US$14.4 billion in 2005 and US$17.0 billion in 2006 [*The Japan Times* (2005)]. As another example, Vietnam plans to expand its electricity capacity from the present 11,400 MW to 25,000 to 26,000 MW in 2010 [*Xinhua*, 2005].

Objectives of Paper

The paper has the following objectives:

1. to identify the trends in, and prospects for, the construction market in the South-East and East Asia region

2. to highlight the factors influencing these trends and prospects

3. to consider the implications of the trends for Singapore E&C firms

4. suggest possible bases for the formulation of strategies which Singapore firms cand adopt to compete in this market.

Research Method

The study is based on a review of the recent literature on the international construction market, and structured face-to-face interviews with professionals and senior managers from firms belonging to the E&C value chain as well as representatives from the E&C industry associations and government bodies.

A list of questions, which had been developed on the basis of a review of the literature, was sent to the interviewees beforehand to serve as a guide. The questions reported on in this paper were:

1. What are the likely trends in the future engineering and construction (E&C) markets in Southeast/East Asian (SEA/EA) in the next 3-5 years?

2. Which are the three most important factors that will shape future engineering and construction (E&C) markets in Southeast/East Asian (SEA/EA) in the next 3-5 years?

Although the questions comprised broad, industry-level ones and those specific to enterprises, the interviewees were requested to answer the questions from the perspective of their firms.

The interviewees were Chief Executive Officers or Senior Managers of general building firms, engineering design firms, quantity surveying consultancies, architectural firms, and financial institutions. The Presidents of three professional institutions and trade associations: Singapore Institute of Architects (SIA), Association of Consulting Engineers Singapore (ACES), and the Singapore Contractors Association Limited (SCAL) were also interviewed. Also interviewed were Senior Managers of statutory boards in charge of the promotion of construction exports: the BCA and International Enterprise Singapore (IE Singapore).

E&C MARKET TRENDS AND INFLUENCING FACTORS

E&C Market Trends in South-East and East Asia

The views of the interviewees were sought on the important trends the future E&C markets of Singapore and the other countries of Southeast and East Asia, from the point of view of a Singapore E&C firm.

The interviewees perceived four positive trends developing in Singapore that will strengthen and increase the business of local E&C firms abroad. First, an increasing number of consortiums are being formed among small and medium sized (SME) firms along the E&C value chain to pursue opportunities overseas.

Singapore firms are using the consortium approach to supplement their capacities and capabilities, to attain the critical mass in terms of size, resources, expertise and experience for overseas markets. Ofori et al. (2005) report on these consortia. An interviewee, who is a director of a construction company, noted that "for Singapore firms, if they do not have the investment dollars, then they must form a consortium."

Second, an increasing number of free trade agreements (FTAs) are being signed by Singapore with other countries, especially those in the region. The countries include Australia, Japan, South Korea and the US. These FTAs open up business opportunities for Singapore enterprises. The third trend is that the perspective of construction professionals in running business enterprise is changing, and the regional market is clearly within their strategic sights. Finally, as a result of the three trends, an increasing number of Singapore E&C firms are extending their business operations in the South-East and East Asian regions.

The interviewees identified several positive trends in the E&C market in South-East and East Asia. The opening up of China's market following its accession to the World Trade Organisation (WTO) was the first trend highlighted. The interviewees expected the potentially huge volume of construction demand in China to offer business opportunities. Second, the returning overseas Chinese will help the country to 'leapfrog' in terms of technology and business acumen. A third trend mentioned by the interviewees is the fast pace of development of the countries in the Southeast and East Asia region. It was noted by the interviewees that, in most of the countries in the region, clients and users are growing wealthier, and the peoples are demanding better housing units and related built facilities. One interviewee noted: "Today, nobody wants a roof over their heads. What they want is the lifestyle."

A fourth driver is an increasing demand for more, and higher quality building and infrastructure works other than housing such as schools, hospitals, factories and hotels. In particular, there is an increasing demand for industrial projects in Malaysia, Indonesia and Thailand as multi-national corporations are increasing their investment in the region where production costs are lower. The increasing awareness of the citizens in the region of "green" issues, and the health consciousness of the citizenry in countries such as China is the fifth trend in the construction market in the region. This has increased the demand for environmental projects such as waste water treatment and bio-waste projects. As one interviewee noted:

> There is also an increased "Green consciousness" in both India and China. This has spawned increased demand for waste water treatment and biowaste projects.

The interviewees believed that the much reduced construction market in Singapore is more than made up for by the larger and growing E&C markets of countries in SEA and EA. There was much optimism over the construction markets in China and India. An Architect with many years of experience doing business in China noted:

> The market for construction in China is highly protected. However, they want quality work that they believe the managers of Singapore can do. I am involved in design in China and my clients want me to get Singapore constructors and managers to do it. I saw this need of China coming a long time ago. We sponsored three years ago a student here and she served her bond with us by working in China for one and a half years and in Singapore also for the same period. Now, I am planning a new division in the company and I need to hire 4 to 5 project managers and quantity surveyors for China.

A Senior Manager of one company said that the firm strongly believes that Southeast Asia is the best place for it to focus on. The firm has jobs in Indonesia, Malaysia, Thailand and Vietnam. The manager gave three reasons why the firm must be in Southeast Asia: (a) confidence has returned since the 1997 crisis; (b) apart from Malaysia and Thailand, the region's countries lag behind in infrastructure provision – "Vietnam is improving ahead of Laos, and Cambodia, and the Philippines will catch up as the recent

Presidential elections will give it [political] stability. He noted that the country "can't stay behind"; and (c) there are opportunities for developers in Singapore because of the size of projects and the nature of the market are more appropriate.

A trend in the procurement of projects is that of finance-led initiatives. Privatised projects and public-private partnerships, which are taking different forms in the countries, and are becoming increasingly common are examples of these forms of projects. In some cases, E&C practitioners, entrepreneurs and venture capitalists are structuring projects, and then seeking clients for these works. This idea of business development may involve the E&C firms taking part in the project as equity investors. Another trend is that clients are increasingly requiring E&C enterprises to add value to their projects. In many cases, the latter achieve this with the co-operation of local service providers of the E&C value chain.

The interviewees highlighted three negative trends in Singapore's E&C market. First, demand for construction was not expected to grow in the medium term and the construction industry was maturing. A major contributory factor to this development was identified by the interviewees as the second trend, that of a demographic problem in Singapore where an increasing proportion of aged in the population, and a falling number of babies is leading to a decline in the rate of growth of the national population; this can cause a further decline in the demand for construction projects in Singapore. The second trend identified was that of increasing competition in the domestic market from Japanese contractors, especially for civil engineering works.

The interviewees also pointed out two negative trends in the Southeast and East Asia construction markets. First, clients are demanding project finance from contractors at the bidding stage. This puts the Singapore firms at a disadvantage as they do not have the financial resources, or the experience in offering such packages. The second adverse trend is increasing competition from China for the inflow of foreign direct investment.

Further Aspects of Developments in E&C Markets in Southeast and East Asia

Other positive trends in Southeast and East Asia were likewise expressed by the interviewees and these include the following:

> The countries in the region are developing quite fast. Governments are putting the economic development reforms to improve the standard of living of their nationals (e.g. China and India). Their income levels are raised. To sustain the economic development of these countries, infrastructure and housing conditions, town planning for their city, *et cetera*, are needed. This also improves the city landscape.

Particular parts of the region with the best prospects were identified by the interviewees. There were some other countries apart from the usual ones. The subregion which received much attention was the Mekong River Valley and Delta, the countries in which have concluded an agreement for common economic growth. The transition in the countries from ideological purity to a desire to improve the wellbeing of their citizens was highlighted. One interviewee noted:

> The Mekong Valley (Laos, Cambodia, Vietnam and Thailand) show good promise. The leadership in Thailand is good. Thailand is the safest bet but not as raw for E&C and not as bright as Vietnam and Laos. In the past, the countries of Laos, Cambodia and Vietnam were preoccupied with power grabbing. Now they are working together to get their country up. Lessons can be learned from Malaysia, Thailand and Singapore. The countries of the Mekong Valley note that infrastructure development benefits the country, especially the BOT type.

A better, and more settled political atmosphere in many of the countries in South-East and East Asia was seen as a driver of the E&C market in the region. The increasing political stability was the result of successful peaceful elections which had led to increased business confidence in some of the countries.
One important trend is the expanding market in Indonesia, Thailand, Malaysia, Vietnam,… The political landscape in these countries has changed. In the 1980s, single leaders held to these countries. The huge population base of these countries make up about 2 billion people. Political stability is growing in these countries. E&C will expand tremendously.

The economic prospects of the countries are considered to be bright. In particular, they are able to attract significant volumes of FDI. One interviewee noted:

> The countries in SEA are very attractive to MNC in terms of their costs profile. These MNCs will provide a market for architectural services as they build factories, offices and residential projects. Singapore, being a role model in the region, will be able to showcase its expertise.

Factors Influencing Market Trends in SEA and EA

In the study, the views of the interviewees were sought on the important factors that will shape future E&C markets in SEA/EA. One positive influencing factor for Singapore E&C firms in their overseas ventures that was referred to by most interviewees is the "Singapore brand name". As the President of one of the professional associations aptly put it: "We have developed a Singapore brand name. The country's built environment was done at a fast pace – in a few years. We have a showcase of advantages in efficiency, speed, and good quality work." What has contributed to the development of the "Singapore" brand name? An Executive Vice President of an engineering design consultant firm notes that "Singapore has a good reputation. It is well regarded for being clean, good and compliant." A Managing Director of a construction firm highlighted the important role of the government in developing the brand name: "Our export strength is in the government's making Singapore have a good reputation."

However, there are a number of negative factors that dampen the competitiveness of Singapore E&C firms as they endeavour to win projects abroad. One weakness mentioned by many interviewees was the absence of an Export-Import (EXIM) bank in Singapore which puts them at a disadvantage when competing with firms from other countries which obtain often subsidized export credit insurance cover from such national institutions. Said two interviewees:

> Financial markets are very important to go overseas – the EXIM banks. If there are no funds from government – even seed money – it is very difficult to go overseas. Seed money is especially needed by contractors.
>
> Most countries have export credit support from the EXIM Banks. I'm not talking about subsidizing because it can be abused. It [export credit] should be fairly priced, but sensitive to risk. It must help firms come to a level playing field, a more competitive level. It must be within the band of commercial return, but at the lower end.

The interviewees noted that the Southeast and East Asia markets are also shaped by both positive and negative factors. One notable positive factor is the increasing foreign direct investment entering China and some countries in Southeast Asia which will spur the development of a wide variety and complexity of E&C projects.

The interviewees identified three negative factors that could wipe out the attractiveness of markets for business. The first factor is international terrorism which has been affecting some of the countries of the Southeast Asian region. As was succinctly put by a manager of a government agency: "The one instability factor is still terrorism." The second potential negative factor is constituted by health related diseases caused by viruses spreading across international borders such as SARS and avian influenza. The final negative factor is the lack of a system for real estate and project ownership and development in most of the countries in the region.

Trends in Singapore Market Fuelling Export Drive

The study determined factors in the construction market in Singapore providing an impetus for the perceived increase in the desire of managers of E&C firms to export their services to countries in the region which has been highlighted above. These included both positive and negative trends in Singapore. One interviewee suggested that for Singapore firms, the push factors are more significant than the pull factors. He observed:

> What are the most important push factors: (1) the lack of work in Singapore; (2) where developers are going is another factor (80% of our clients are those from Singapore and Malaysia who are going to China and India); and (3) the third factor is the adjustment required from taking a professional perspective to a business perspective.

Among the push factors, the reduced level of demand was most highlighted by the interviewees. The large number of firms in the larger categories in the Singapore construction industry was considered to be a problem for all the firms. One Contractor noted:

> In the next 5 years, we think that Singapore will reach a level of saturation. We are an A1 contractor, but there are too many A1 contractors in Singapore. (…) Too many of us are A1 (35 total count). This is still too many. These companies do not have business strength only construction strength.

The problems relating to the large number of firms in the top financial categories is further exacerbated by the strong presence of foreign firms in that segment of the industry in Singapore. Two of the Contractors interviewed highlighted the greater resources of the foreign firms which makes them formidable competitors for their local counterparts, by noting:

> MNCs dominate the infrastructure projects by driving down to win the project. …The day they sign the contract, they start to lose money. Japanese are committed; [they] will complete the project even if they lose money.
>
> The future is difficult here because of competition from Japanese construction companies. Look at the MRT Circle Line[2]. The Japanese are losing S$20 million upfront. In Japan, the contractor is losing market share so they are using their international market to boost the company's performance.

Another factor highlighted was demography. Singapore's population has not been growing at the rate considered to be necessary for sustained economic growth. One interviewee, an Architect, noted:

> I am afraid that the future decline in the construction industry of Singapore is because of the demographic problems that it may face in the future.

[2] MRT Circle Line is the latest phase of the Mass Rapid Transit (MRT) system of Singapore, an urban railways system, much of which is underground.

CONCLUSIONS AND RECOMMENDATIONS

There will be increased opportunities for construction firms in the South-East and East Asia regions in the medium term but there will be significant challenges. Singapore E&C firms must obtain projects overseas as there are poor prospects for an upturn in the domestic market in the near future. The firms need to adopt appropriate strategies to enhance their competitiveness. There will also be stiff competition as the market will attract some of the best E&C companies from around the world.

The Singapore E&C companies must take action in several areas to build up their capacity and capability to export their services. There must be concerted action by both the state and the industry, based on a long-term strategy and a set of incentives. The firms must continue to build up a good track record and reputation at home. They can take advantage of niches resulting from Singapore's accumulated development programme; these may be geographical, technical, client type, or unique service, etc.), to differentiate their products and services. They should also develop corporate strategies and initiatives based on the government's promotion and support programmes. The firms must also take action to address their negative features in relation to international projects, including building up their size and financial resources, and continuously developing their managerial skills in areas where they are weak, such as in financial management. The firms must identify, and continually improve their core competences. They should benchmark themselves against the best firms in their fields at home and abroad, and emulate exemplary firms. The firms should continue to seek strategic value-chain partners and collaborators to supplement their expertise and resources.

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Sustainable Construction in Chile: a diagnosis

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Abstract
The construction sector plays an important role in the sustainable development of a country. However, in Chile, activities in the field of sustainable building practices are still in a preliminary phase and specific legislation in this area barely exists. Only little information on sustainable building activities is documented and available. The aim of this paper is to explore the efforts taken by the government and the building industry towards environmental building practices, enabling the generation of policy-ideas for the future improvement of the status of sustainable construction in Chile. The paper includes information about the current government response in the form of policies and policy instruments, the industry actions regarding sustainability, and the environmental awareness of designers, contractors, and the government as it is demonstrated by the attitude of these actors towards the environment. Finally, barriers to sustainable construction practices are also reported. An interesting conclusion obtained from this research effort is that there is a mismatch between the industry's vision and the government perception on the constraints towards environmental building practices in our country.

Keywords
Sustainable construction, government, diagnostic, barriers.

INTRODUCTION

The debate on the environmental consequences of economic growth and the importance of sustainable development has moved up the international agenda. This has been reinforced by trade liberalization and increasing globalization of the world economy. It is a direct response to the global problems of natural resource depletion and degradation, waste generation and accumulation, and environmental impact and degradation (Vanegas, 1998). The construction sector is one of the largest sectors in terms of resource consumption and waste production in the world. Therefore, sustainable building is an essential factor in achieving sustainable development (Sunikka, 2001). During the World Summit on Sustainable Development 2002 in South Africa, Agenda 21 for sustainable construction in developing countries was published. This shows the increasing interest and the need for focusing on the process of sustainable construction in less developed countries.

Chile is still considered a developing country, although qualified as an upper middle-income country by the World Bank. This implies on the one hand that the process of economic growth has increased the pressures on the environment and on the other, that the government has the means to begin acting on sustainable development. In this context, the challenge for Chile, and comparable countries, is to protect and conserve the environment without undermining the economic development.

DESCRIPTION OF THE RESEARCH

The main goal of this research was to carry out a study of the status of construction sustainability in Chile. To achieve this it was necessary to find out a useful and practical methodological approach. This methodological approach had to consider how to transform information obtained from opinions, facts and literature, into measurable indicators. Sustainability is a multidimensional concept, which needs more than one indicator to be characterized.

The research instrument of this study was then developed by means of defining construction sustainability development indicators. These indicators might be especially useful for policy-making. Namely, with the help of these indicators, information on environmental problems is supplied in a structured way, providing a solid basis for the formulation of conclusions. The use of sustainability indicators could enable policy-makers to evaluate the seriousness of different problems. A second advantage is therefore that the identification of key factors causing pressure on the environment would support policy development and priority setting. Finally, and not the least important, the effects of policy responses can be monitored

The response variable for sustainable construction in Chile was divided into:

- Government response, in the form of policies and policy instruments, facilitating, stimulating, and regulating the actual environmental protection process,
- Industry response, as being the environmental protection process defined as all actions and measures taken by designers and construction companies directly for reducing pressures on the environment, and
- Environmental awareness, referring to environmental awareness of designers, construction companies, and the government. It reflects the attitude of these actors towards the environment.

The construction industry is represented by designers and construction companies. Their response is expressed by actions and measures taken to protect the environment. The response of the government is taking shape in the form of an environmental policy directed towards the building industry. Table 1 serves as an introduction to the operationalization of the response variable.

Table 1. Global indicators of sustainability development

STATE OF SUSTAINABLE CONSTRUCTION	
Government Response	Direct regulation Indirect regulation Self regulation
Industry response	Environmental considerations in design process Environmental considerations in production process Advances in technology
Barriers	Knowledge/ attitude Market / financial Process / technology Government / policy

Data collection

Three different data collection methods were used for this research. First, literature was used to describe the context of actions taken in the policy field as well as in the construction industry. Most of the information came from the libraries of the National Commission of the Environment (Comisión Nacional del Medio Ambiente, CONAMA) and the Chilean Construction Chamber (Cámara Chilena de la Construcción, CChC).

To determine the government response, key persons from the policy field were interviewed. Few public organizations related to the construction industry were relevant for this research. The topics included in the interview were: 1) to what extent the construction sector is considered to be a producer of pollution, 2) which policy instruments regarding sustainable construction are currently available, 3) what have been the impact of these instruments and the legal power of public organizations, 4) future developments, and 5) barriers to sustainable construction.

The organizations included in the study were the Ministry of Public Works (Ministerio de Obras Públicas, MOP) and the Ministry of Housing and Urban Development (Ministerio de Vivienda y Urbanismo, MINVU). Furthermore, key-persons from the National Commission of the Environment, and the National Council of Clean Production (Consejo Nacional de Producción Limpia, CPL) have been interviewed.

The third data collection method was a survey used for measuring the attitudes and opinions of construction people towards sustainable construction practices. Two groups of stakeholders of this sector were included in this research, namely; 1) construction companies, and 2) designers.

Most questions have a categorized rating scale and some have a comparative one. A five-point scale was used in case.

RESULTS

Government response
From the response of the government, the following can be concluded.

The most important direct policy instruments are the designation of waste-yard places, the environmental impact assessment regulation (EIA), and the thermal regulation for housing. No norms are specifically dealing with construction and demolition waste, although some rules are available regarding the transport of dangerous waste. Recently, four waste-yards were made available in Santiago for construction waste by the government. The EIA is applicable to large investment projects both, public and private, and controls the fulfillment of environmental regulation. In practice, building projects are not subjected to the EIA. The thermal regulation as yet is only applicable for the roof design of houses. In the near future, regulations are planned for the other parts of buildings envelope.

With regard to indirect policy instruments, it can be concluded that pricing and tax related policies are non-existing in Chile. Opinions differ on the possibilities for the application of these instruments in the design of environmental policies. Important barriers are the article in the Constitution that prohibits decisions on the destination of general taxes, and the lack of knowledge on the implementation of economic instruments at policy level in Chile.

The Chilean government also makes use of self-regulation instruments. In this context, it is promoting the application of a Clean Production Agreement for the construction sector. This agreement is applicable to construction companies and deals with the themes of dust (particular matter), noise, and solid waste. In addition, some information provision in the field of sustainable construction takes place. The most important information provided by the government, are the three demonstration projects of the Ministry of Public Works showing their architects how environmental aspects can be integrated in the design phase. The demonstration projects are still in the design phase and no evaluation or information diffusion has been put in practice yet. The Chilean Construction Chamber provides environmental information in the form of three manuals for construction companies on how to minimize the effects (dust, noise, and solid waste) of construction activities.

The objectives and target groups of the most important current environmental policies in Chile are summarized in table 2.

Table 2 Objectives and target groups of environmental policies

<table>
<tr><th rowspan="2">Target group</th><th colspan="2">Objectives / themes</th><th rowspan="2">Policy instrument type</th></tr>
<tr><th>Energy</th><th>Solid Waste</th></tr>
<tr><td rowspan="2">Designers</td><td>Thermal regulation (MINVU)</td><td></td><td>Direct regulation</td></tr>
<tr><td>Demonstration projects (MOP)</td><td>Demonstration projects (MOP)</td><td>Self regulation (information provision)</td></tr>
<tr><td rowspan="2">Construction companies</td><td rowspan="2"></td><td>Related norms, landfills</td><td>Direct regulation</td></tr>
<tr><td>Clean production agreement</td><td>Self regulation</td></tr>
</table>

As a general conclusion, it can be stated that the current available environmental policy is based on direct policy instruments and only partly covers the construction sector. This part is focused on the construction process and related themes of dust, solid waste, and noise. Finally, there is a lack of attention for embodied energy in material issues in current environmental policy.

As an overall conclusion on environmental awareness in the policy field, it can be stated that this is not sufficient. Interest for and knowledge on the environmental theme in general and environmental building practices in particular is missing at the Ministry of Housing and Urban Development. The Ministry of Public Works is a little more preoccupied with the environmental theme which is reflected by some few actions like the creation of the Environmental Administration office and the participation in demonstrations projects. A positive development is the growing attention given to environmental issues by the Chilean Construction Chamber.

The key-persons in the policy field see most barriers against construction sustainability in the sphere of knowledge and attitude. According to them, the lack of awareness and knowledge in Chile in general and in the industry is an important constraint towards environmental construction practices. Directly related to this, a lack of attention in the educational system of Chile is also considered a big constraint. As the second most important group of barriers, the key-persons mentioned financial and market constraints. A main aspect is the short-term thinking of the decision-makers versus the long-term stretch of sustainability. Less significant constraints are of a technology or policy nature, although a lack of interest at policy level was mentioned.

According to the same stakeholders, a first solution to face these constraints is education. Universities should play an important role in this by offering integrated sustainability education. The opinions on which policy instrument types will be most effective differ significantly. Three individual recommendations are: 1) to increase the application of prefabrication and industrialization, 2) a leading role by the government, and 3) monitoring data on environmental impacts.

Building Industry response

This section presents the actions taken by designers and construction companies as a response to the demands of construction sustainability.

Designers

The designers' environmental construction practices are divided into 1) energy concerns in design, 2) application of energy saving measures, and 3) waste and material considerations in design.

As shown in figure 1, the application of roof insulation design scores higher than the three other groups. According to respondents, in 90% of their projects roof insulation is applied. Walls are insulated in 65% of the cases, windows (meaning the application of double glass) in 40% of the projects, and still in 30% of the projects floor insulation is applied.

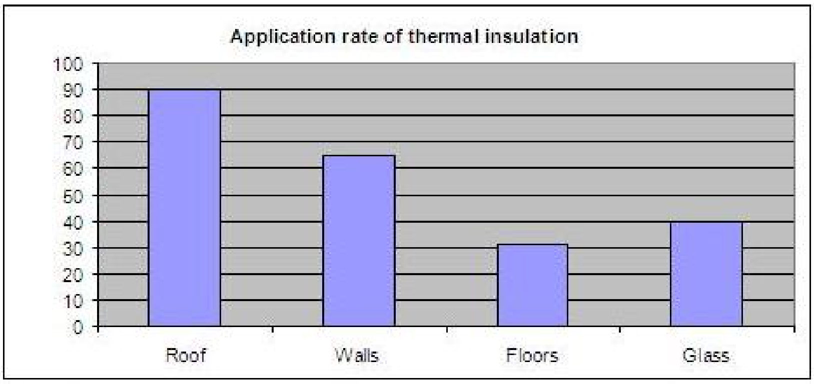

Fig. 1 Energy concerns in design

Figure 2 shows the energy-related issues addressed by design practices. The long-standing basic design concepts of orientation of the building to the north and natural ventilation are most often applied, probably also due to the easiness and low costs for their application.

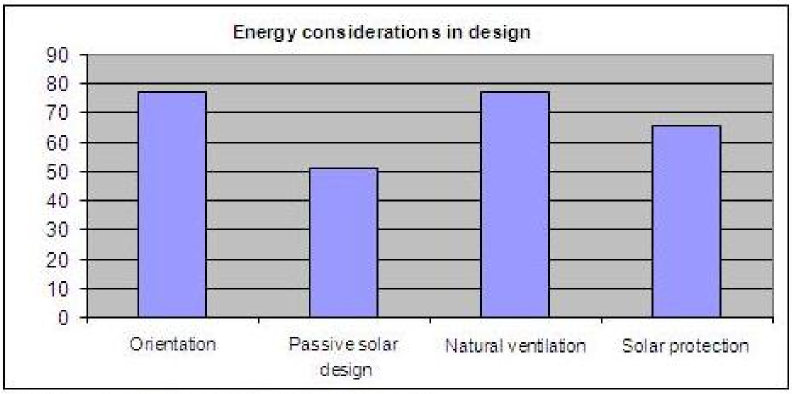

Fig. 2 Energy issues in design

As shown in figure 3 the use of standard building material scores extremely high in relation to the other waste and material considerations in design. According to respondents, about 86% of the projects are designed using standard building materials. Renewable materials and recycled materials are only used in respectively 5 and 10%.

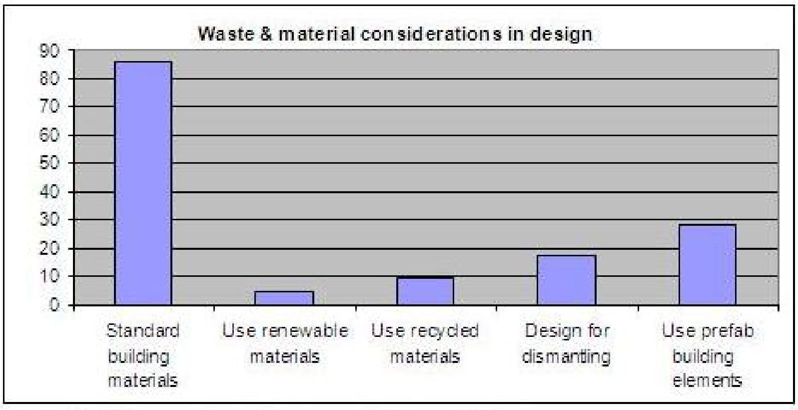

Fig. 3 Waste and materials considerations in design

Construction companies

The construction companies' environmental response is divided into 1) implementation of environmental measures, 2) waste and material considerations on site, and 3) adoption of environmental technologies.

According to the survey's respondents, on 72% of the projects measures are taken to prevent or reduce the environmental impact of material waste. A lot of measures have also been implemented to reduce the occurrence of dust (70%) and noise (57%). See figure 4 for an overview of the implementation rate of more environmental measures.

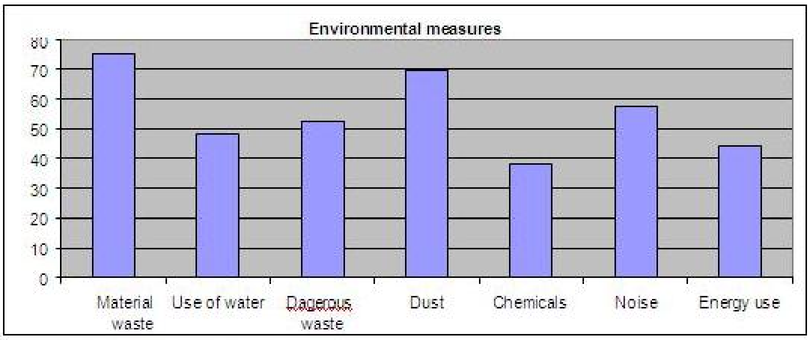

Fig. 4 Environmental actions

Figure 5 shows the degree of waste and material considerations taken in the last three years. In 87% of the projects, no more materials than needed are purchased. The high score for "construction not taking place on the construction site" would suggest that in 57% of the projects assembly of construction materials took place instead of pouring of concrete. As the building construction industry predominately uses concrete and masonry in their work, respondents probably misunderstood this question. Direct reuse of materials on site occurs in 40% of the projects. The separation of waste on site happens in 33% of the cases and prefabricated building systems are used in 31% of the projects.

Fig. 5 Material and waste considerations

Construction companies were also asked whether they have implemented clean technologies to prevent contamination with regard to energy saving, solid waste, noise, dust, and efficient water use. As figure 6 shows, most technologies are dealing with noise and dust. 79% of the respondents implemented at least one technology to reduce dust in the last three years. 64% implemented a technology to reduce noise. Energy efficient technologies are rarely implemented (12%).

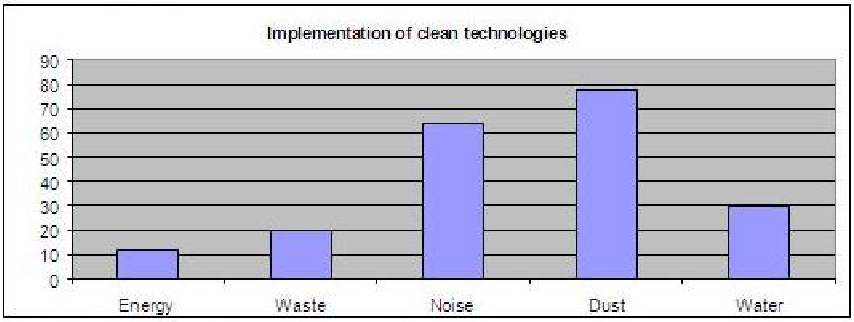

Fig. 6 Application of clean technologies

Asked about the kind of support that would incentive them the most to apply environmental construction practices, both the designers as construction companies mentioned a discount on taxes for companies that invest on sustainability practices as their first choice (31% vs. 63%). The second choice was the direct regulation (48% of the designers and 37% of the construction companies). Figure 8 shows a summary of these opinions.

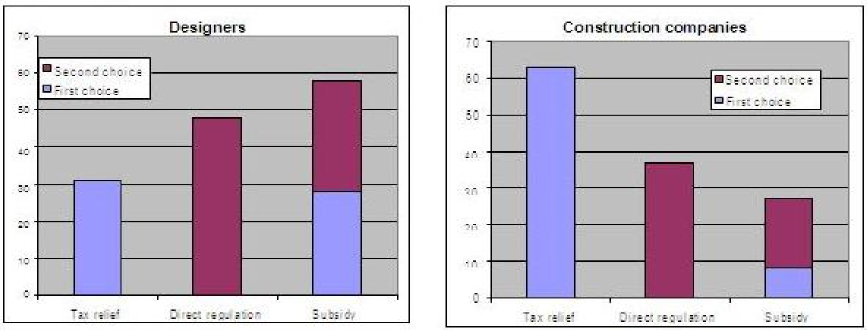

Fig. 8 Opinions on incentives for construction sustainability

Barriers for sustainable construction practices

The top-five barriers according to respondents from construction companies are presented in table 3.

Table 3 Barriers and constraints – construction companies

Barriers & constraints according to construction companies

Top-five	Barrier	Average score of:	Constraint field
1.	Lack of government support	73%	G
2.	Bureaucracy	70%	G
2.	Lack of integral design	70%	T
4.	Price structure does not reflect environmental costs	69%	F
5.	Economic aspects have priority	68%	F

K = Knowledge/ attitude barriers, F = Financial/ market barriers, T = Technology/ process barriers, G = Government/ policy barriers.

The top-five barriers according to the designers are quite similar to the constraints mentioned by construction companies (see table 4).

Table 4 Barriers and constraints – designers

Barriers & constraints according to designers

Top-five	Barrier	Average score of:	Constraint field
1.	Lack of government support	72%	G
2.	Bureaucracy	68%	G
2.	Lack of integral design	66%	T
4.	Focus on investments costs (short-term vs. long-term)	66%	F
5.	Perception of high costs	65%	T

K – Knowledge/ attitude barriers, F – Financial/ market barriers, T – Technology/ process barriers, G – Government/ policy barriers.

Significant difference was found in the opinions of respondents when classifying the design companies by size. In all the cases the small and medium -sized firms (annual operational volume till US$ 5 million) considered barriers as bigger constraints than larger firms do. These barriers are:

- Financial: economic aspects have highest priority
- Technology: lack of knowledge on how to implement sustainable practices
- Technology: lack of integral approach in design
- Policy: lack of government support.

With regard to construction companies, only in one case a significant difference was found between small and medium-sized companies (annual operational volume till US$ 10 million) and big companies. The small and medium-sized firms see a higher barrier in the policy constraint:

- Policy: inconsistency in behavior between different governmental agents

CONCLUSIONS

The government response was measured by means of a desk research and interviews with key-persons from the policy field. The influence of current policy instruments was determined by linking the results of the government response with those of the industry response. The following environmental policy characteristics were determined:

- There is a very narrow coverage of the construction sector in environmental policy. The current legislation is focused only on the construction process and related themes of dust, noise, and solid waste. A start has been made with thermal regulation for the roof design of houses. This regulation has had a positive influence on the industry, resulting in 80-90% application of it.
- In addition, the current legislation is spread over several institutions. No particular organization is responsible for sustainable construction.
- Finally, the policy is focused on direct policy instruments and self-regulation. Indirect policy instruments are almost non-existing in the Chilean environmental policy. The most important example of self-regulation is the Clean Production Agreement (APL). The APL is effective regarding themes that dealt with noise, dust, and waste, but has no impact on a total improvement in environmental construction practices.

The building industry response was mainly determined by means of two questionnaires. The results of this survey indicate the following conclusions:

- The environmental building practices of construction companies are focused on three themes: solid waste, noise, and dust. Waste separation on site and the use of prefab building systems are least often put in practice. By judging the construction companies on an environmental friendliness scale, it can be concluded that 60% of the construction companies consider the environment in less than half of the projects. Only 6% considers the environment in 75% of the projects.
- In general, designers more often take energy considerations into account than waste & material considerations. The orientation of the building to the north and natural ventilation, are mostly considered. Moreover, designing with standard building materials often takes place, which has significantly contributed to a decrease of C&D waste. On the environmental friendliness scale, 42% of the designers operate environmental unfriendly, meaning they consider the environment in less than half of the projects. 6% considers the environment in 75% or more of the cases.
- The discrepancy found in knowledge & interest level versus responsibility level of almost all stakeholders in the construction process, indicates a general lack of interest in and knowledge on how to carry out environmental building practices within the industry.

The most important constraints towards sustainable construction practices include:

- The lack of environmental awareness and knowledge in Chile in general and in the construction industry in particular;
- The lack of government support, especially regarding the small and medium-size design companies;
- The lack of the application of integral designs;
- The lack of assistance in relation to environmental norms and rules provided by government agencies;
- The scarce environmental information available.

Moreover, it was concluded that technological factors do not form a barrier to sustainable construction in Chile. Finally, a mismatch between the industry’s vision and the government perception on the constraints towards sustainable construction practices was detected. The key persons in the policy field consider the lack of industry environmental awareness and education as the most important barriers, while the building industry considers the problem to be found in the government policy field.

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Estimating Municipal Infrastructure Project Cost

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Abstract
In developing countries it is often very difficult to estimate the cost of constructing municipal infrastructure because the legal environment and public policy often dictates that the government act as the general contractor for the work instead of allowing independent private contractors the opportunity to participate through competitive bidding. This practice is based on the premise that it eliminates the payment of profit and overhead to the contractor and the method should therefore permit project economy—less cost to construct. However, if public agencies are not competent in managing such work the supposed savings are not realized. This research focused on identifying the "real" saving when government manages the construction of public infrastructure and in determining the principal factors that influence municipal-infrastructure project costs. Using information from approximately 500 public infrastructure projects built by the Piura Municipality in Peru between 2000 to 2004, government policies, public contracting systems, causes of additional costs during construction, and the number of delay days were related to the additional construction costs experienced. This research should help engineers to focus their efforts in estimating the construction costs of public infrastructure projects and change their attitudes about government policies and public contracting methods.

Keywords
Estimating, estimating project costs, government policies, public contracting systems.

INTRODUCTION

Large capital projects, in Peru and around the world, that are undertaken by government agencies are generally very important to the economic growth and development of the communities involved. In Peru, the execution of many infrastructure projects is the responsibility of municipalities that have limited financial resources. Therefore, it is very important that the cost of these projects should be estimated accurately and the work be managed effectively. Project cost overruns can affect completion of the work and can additionally impact the accomplishment of others projects because of budgetary limitations. Research has demonstrated that certain construction and construction management factors directly affect the cost of project execution, but those factor are not the same found in other international research (Merewitz, 1973).

Contracting Methods

Annually, the Municipality of Piura, in northern Peru, spends approximately $3,000,000 for infrastructure projects. One of two contracting methods is used for the execution of those projects: 1) low bid by independent contractors and 2) direct hire of labor and equipment by the municipality, which also necessitates direct administration of the work—construction management—by the municipality.

Individual projects evaluated in this study do not exceed $100,000 total cost, so they can be considered small projects, though they are the same type frequently built. This consideration is specially important, as overruns more than 5% is expected in mega projects [Schexnayder, Weber and Fiori (2003)]. In this small projects no overruns are expected as they are build every year.

A review of project records found that more than 50% of the Municipality's public infrastructure projects experienced additional costs or cost growth as compared to the predicted cost in the estimates prepared during the design phase of project development. Additional costs are items not included in budget nor in drawings. Additional quantities, wrong prices, more costs are not considered as additional costs because are contract responsibility. It was also found that by contracting with private contractors the total cost of many projects was reduced. The objective of these project cost reviews was to identify the factors that influence construction costs and to propose methods for improving project estimate accuracy.

Additional costs are assumed in this study as the difference between final costs at the end of the project construction compared with cost estimated before bidding. In these small and common projects, additional costs are not expected. Plot plans, drawings and specifications are all defined and estimate costs are detailed.

Another important aspect, which was evaluated during the research, was the degree of uncertainty that existed during the design phase of a project. Estimates of project cost should be more precise as design is refined and uncertainty diminishes during project developed. Early budget or conceptual estimates present the highest level of uncertainty because of the lack of project definition. Subsequent estimates made as design progresses should offer more precision as to cost, and reflect the clearer definition of project scope [Schexnayder and Mayo (2004), Peurifoy and Oberlender (1989)].

FACTORS AFFECTINNG MUNICIPAL INFRASTRUCTURE PROJECT COST

In USA, only less than 30% of agencies release complete copy of estimate including quantities and unit prices. But in Peru, all municipalities release this information. This detail is important as Merewitz (1973) found that cost overruns were positively related to diverse factors as incompleteness of preliminary engineering and quantity surveys and inexperience of the administrative personnel. But if municipalities release detailed information, cost overruns should be related to other different factors.

Using information from 566 of Piura's municipal projects:

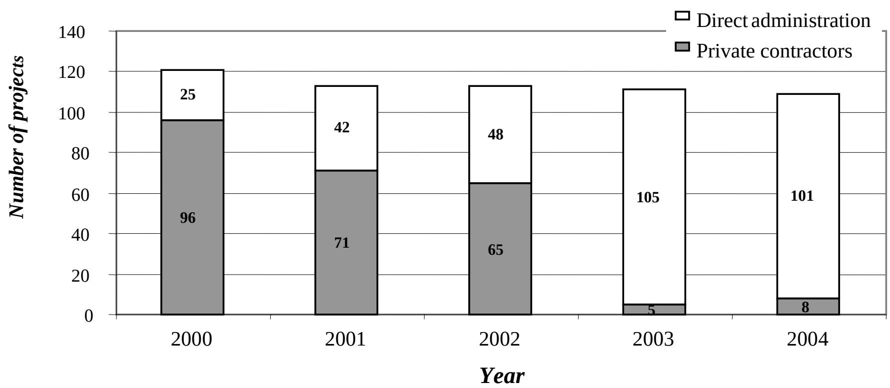
- Initial budget was compared to the final cost for design, supervision, and construction. This was done in the case of both contracted and direct hire projects.

- Preconstruction cost estimates, which were prepared by the designer from the final project plans, were compared against the final project construction cost.
  - In the case of a project constructed by a contractor the estimate would include the total amount paid the contractor (direct cost, overhead, and profit).
  - In the case of the municipality using direct hire and managing the project itself the estimate would only be for direct cost.

Overhead is estimated assuming historic bid prices and some detailed estimates and also a contingency amount to conceptual estimate as about 5% to 45% of total project cost is used in USA [Schexnayder, Weber and Fiori (2003)]. In Piura, standard percentage of total project cost as overhead is assumed (20%) no matter of project type or complexity and contingency amount is not used in Peruvian projects. There are not incentives for early project completion.

Different municipal administrations in Piura have tended to follow opposite approaches for accomplishing infrastructure projects. For the period 2000 to 2002 most projects were bid to private contractors. The administration that came to office in 2003 thought that it was more economical to use a direct administration approach for accomplishing projects. It was assumed that direct administration would reduce cost and also result in fewer problems with the design. Figure 1 presents a summary by year of municipal projects under each contracting method.

Figure 1 Municipal infrastructure projects of Piura.



Figures 2 and 3 show by year and type of contracting method the number of projects that experienced additional cost in terms of the origin construction estimate. If the idea was to reduce project cost and to eliminate cost increases by the use of direct administration the date does not support the assumption. If the system of direct administration was as efficient as assumed, there would be a low percentage of projects under that contracting method with additional costs. Actual experience in Piura was that during the years 2000 to 2003, when externally contracting was the more prevalent method, 66% of the direct administration contracts had cost overruns. This was little improved during the 2003 to 2004 period when direct administration was more prevalent as 54% of the direct administration projects had cost overruns.

Figure 2 Piura municipal projects executed by the direct administration of the work.

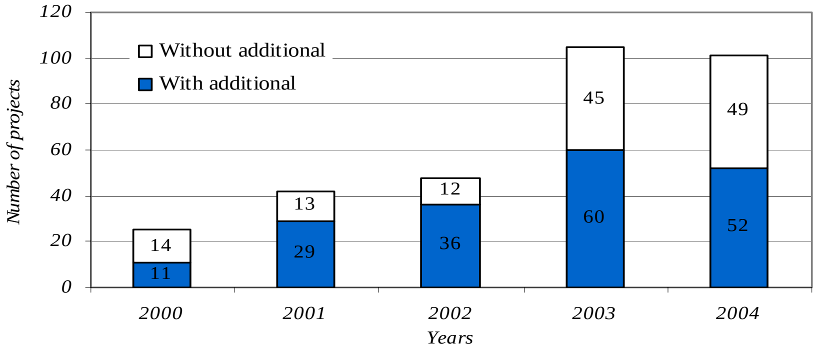
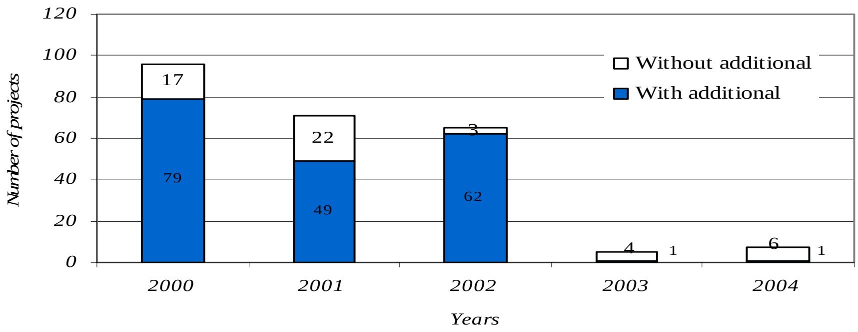


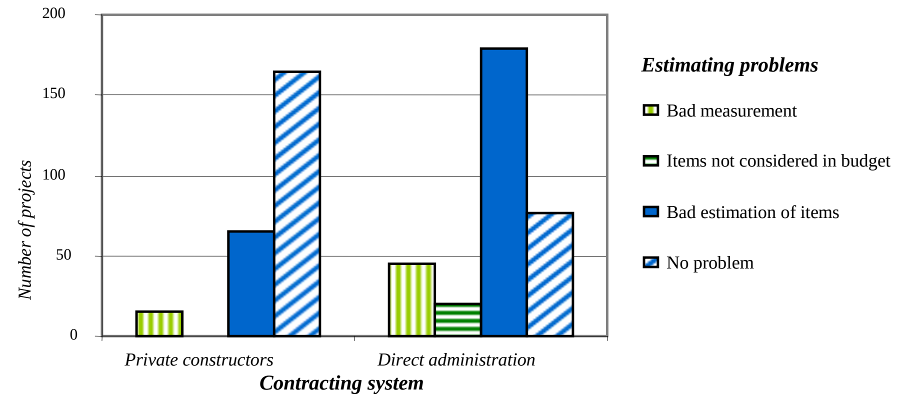
Figure 3 Municipal projects constructed private contractors.



Estimating problems

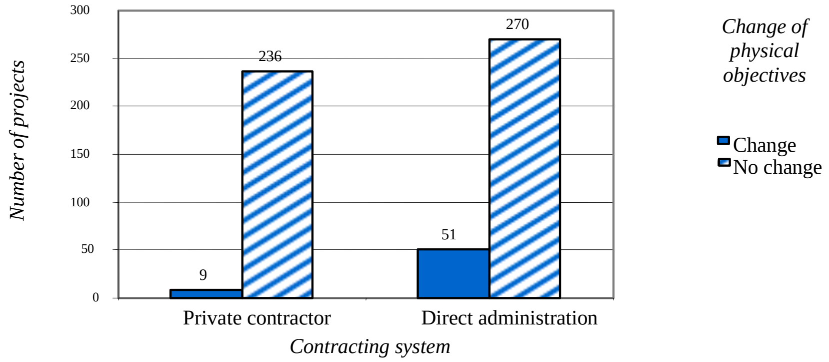
Figure 4 is a summary of the major problems that were identified as the primary causes of the differences between the estimated cost and the final cost of construction. It is apparent that in the case of projects carried out by direct administration there were considerably more estimating problems. These problems were primarily in the areas of labor cost and assumed productivity. With both contracting methods unexpected problems were the cause of cost increases in a small number of cases. These unexpected problems were mostly administrative and geotechnical issues.

Figure 4 Contracting method vs. estimating problems.



Project scope changes (Figure 5) were incurred on 15% of the direct administration projects and only 4% of those projects contracted out to private contractors. This is probably caused by the fact that it is easier to incorporate changes into direct administration type projects as no negotiation of a change order is required.

Figure 5 Contracting method and number projects with scope changes.



The project type and estimate problems

It is more convenient to use the direct administration method of construction when the uncertainty–risk–of the project cost is high, but in that case the government assumes the risk. The projects carried out by direct administration by project type included urban development, building, hydraulic and sanitary works, and roads. During the years 2003 and 2004, there was a tendency to execute more urban development and road projects. In the case of the roads a new pavement technology was introduced and contractors were not willing to assume responsibility for the results of the new constructive processes for which they had new knowledge. This can be seen in Figure 6, which shows the distribution of projects type and contracting method. Figure 6 shows that most of the urban development and road contracts were carried out by direct administration, and other construction works were by private contractors.

Figure 6 Project type vs. contracting method.

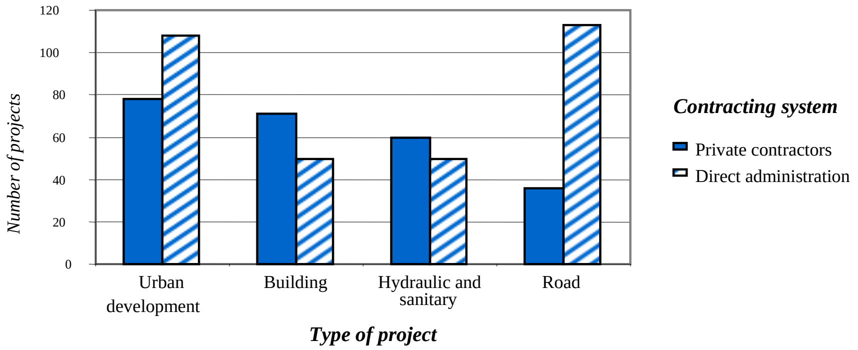
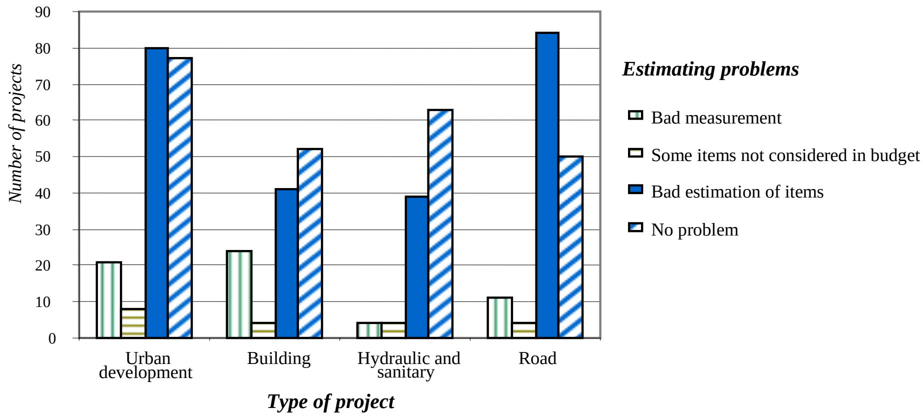


Figure 7 illustrates the more frequent estimating problems by project type. The problem of the incorrect cost estimation of items and the problems of accurately defining project quantities occur at a high frequency in the case of urban development and road projects. In the case of road projects the issue is the difficulties due to the introduction of new construction technology. This found confirm other research findings that any form of technological innovation in a project is likely to resulting cost growth [Sawyer and Merrow (1988)], specially the use of new materials or methods of construction [Merewitz (1973) and Norquist (2002)].

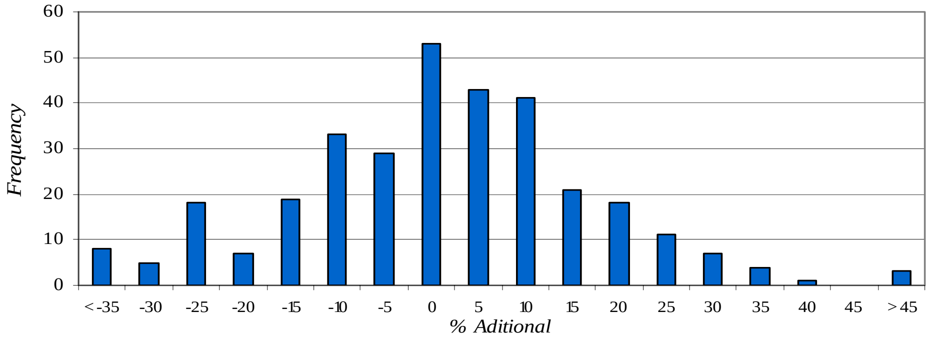
Figure 7 Project type vs. Most frequent estimating problems.



VARIANCE BETWEEN FINAL ESTIMATE AND ACTUAL COST

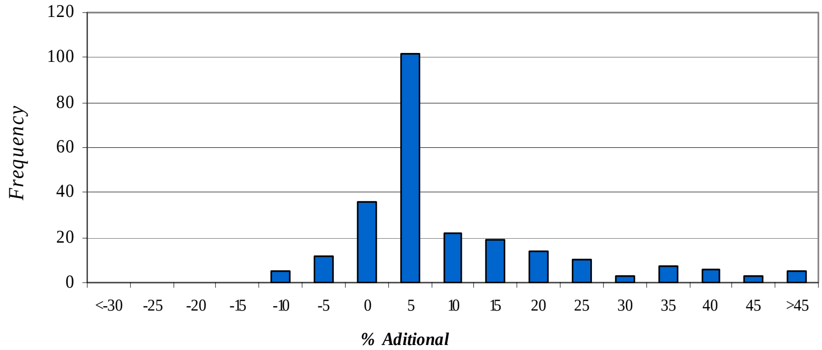
An analysis was made of the difference between the final cost of a project and the final estimate which was prepared by the design engineer at the completion of design. The distribution of frequencies of the percentage variation for those projects executed by direct administration is shown in the Figure 8 and for project constructed by private contractors in Figure 9. When the graphs are compared one gains an appreciation of the wide range of variability that resulted when direct administration of the work was employed to accomplish the construction.

Figure 8 Frequencies of the estimate to final cost percentage variability for direct administration projects.



There were more cases of both overestimation and underestimate of project cost, and the variability is must greater. It has been speculated that the variation between two contracting methods is caused by the fact that in the case of direct administration a saving will be returned to the municipality, however any saving in cost that is achieved by a contractor simply becomes more profit for the contractor. This situation is one of the arguments that municipalities use to defend the direct administration method of accomplishing projects.

Figure 9 Frequencies of the estimate to final cost percentage variability for contracted projects.



The opposite argument can also be made. When there is a cost overrun on a project that is being constructed by the external contracting method it is usually the contractor who must assume the expense. With external contracting the contractor assumed the project risk of delivering the project at the contractual price. However, if the additional cost is the result of problems with the plans or scope of work then the municipality must provide additional money to the contractor.

Award process can limit those ranges of deviation. In USA, review of estimates in project award is frequently made if less than 10% of estimates, or more than 5% or 25% happens [Schexnayder, Weber and Fiori (2003)], but in Piura, only lowest bid price is chosen. If too low, perhaps some misestimating problems could appear, but in that case, probable schedule and its additional costs are contract responsibility. Those additional are not reflecting in final costs.

It is important to mention that in Peru the project cost cannot exceed the estimate by more than 15% without authorization for the central government agency which is providing the funding. Therefore, there is some control on project cost overruns. In both cases, uncertainty or size of deviation as project development follows typical bounds of estimate accuracy [Schexnayder, Weber and Fiori (2003)].

RELATIONSHIP BETWEEN DESIGN/MANAGEMENT EXPENSE AND PROJECT COST

The relationship between design expense and project cost was also evaluated. Designers are contracted to develop a complete technical file, that include a detailed quantities and unit prices budget. Some bad estimate costs could came from a lack of detailed design documents. It has often been stated by designers that complete design or estimate projects can not be approached because not sufficient compensation to perform all the work to the highest standard. If plans or design cost estimate are no in high standard, more problems would be faced by contractors during construction. Therefore, it was anticipated that a greater design fee for the project would correspond to projects being executed with actual cost being close to estimated cost (low additional costs). In Figure 10 additional cost and design fee are both expressed as a ratio respect to estimated cost made with completed plans before construction.

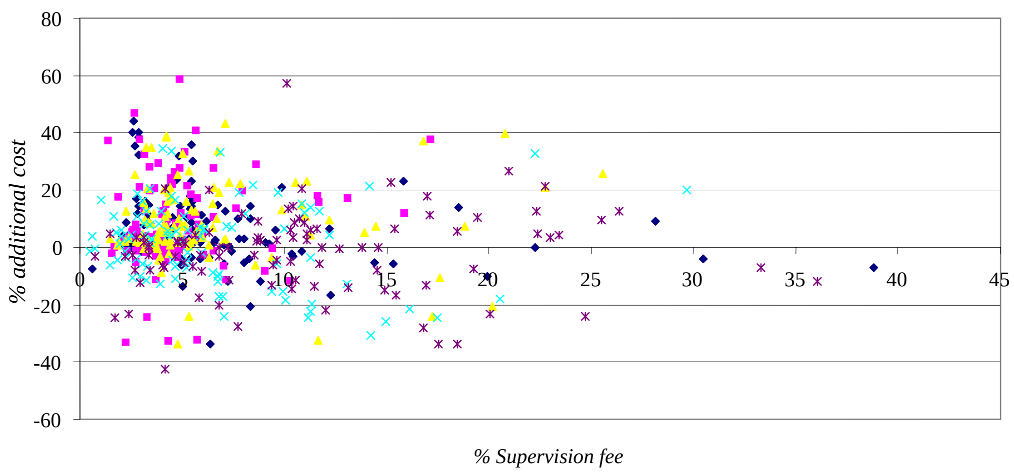
Figure 10 Ratio of design cost to estimated cost compared to final project cost compared to estimated cost.

In the case of Piura data it appears that if the designer receives a fee of 8% or less, compared to the estimated cost, the variability between the estimate and final cost can be as great as plus or minus 40%. In this low fee range there were a few cases where the cost overrun was greater than 40%. However, when the designer's fee is 8% or greater the precision improves to plus of minus 20%.

Similarly, the assumption has often been expressed that there is a relationship between the amount of supervision a municipality exerts during construction and cost performance in relation to the estimate. Figure 11 illustrates this relationship in the case of the data from Piura.

Figure 11 Ratio of supervision expense to estimated cost compared to final project cost compared to estimated cost.

% Design fee



In the case of the supervision it appears that 20% or more must be expended to realize an improvement in actual construction cost compared to the estimate. It is realized, however, that the design fee and the cost of supervision have a relationship to the type and magnitude of the project. Therefore, further research in this area is necessary before any conclusions can bee stated.

CONCLUSIONS

The method of accomplishing construction work - direct administration or the use of external contractors – appears to have a relationship with the actual cost of construction. The most frequent estimate problems identified, by this study of data from Piura, Peru, were inaccuracies in calculating the cost of work items and problems of accurately defining project quantities. Differences in the variability of cost over run/under run variation was observed between the two contracting methods.

Low Bid Price system as Project Award seems to affect contractors, as misestimating problems, items not included in budget nor in drawings, additional quantities, wrong prices, or more costs by schedule are contract responsibility that could appear, are completely contract responsibility. There is no chance even if wrong came from the municipality.

The accuracy of cost estimates seems to be tied to the fee that the designer receives for preparing the plans and specification and creating the final estimate. Therefore, it is recommended that carefully review their fee structures as a method for impacting the quality of project estimates.

Municipalities are very interested in reducing project costs when investing in the public infrastructure it appears that public agencies are not structured to effectively manage projects as private companies that specialize in the business of construction. The data seems to support the conclusion that direct administration often leads to increased project cost.

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The Impact of Economic Globalization on the Spanish Housing Market

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Abstract
Construction industry has a multiplier effect on the economy of each country. Within the construction industry, residential building is the most important: e.g., in Spain, there were 687,000 new residential units built in 2004, which represent 33% of production in construction industry; these figures correspond to 6% of the Gross National Product. The reasons for this boom are: low interest rates, increase of family incomes, demand from immigrants, changes in family structure, perception of housing as an attractive investment alternative, and demand for tourist housing. In Spain, housing prices increased more than in any other country of the European Union during last years. Our work analyzed statistically this evolution and its causes. Thirty three variables were used and a correlation matrix was obtained. It was found that the main explanatory variables were: population growth, income levels, interest rates, and the progressive involvement of the country in the European Union. Spain belongs to the Euro zone, which implies a tendency to standardize the economy of the eleven countries that embrace it; the average income per capita of the Euro zone is higher than that of Spain, thus a smooth leveling is unavoidable, even in the housing market. This economic globalization influences the housing prices evolution through financial markets, migratory and tourist movements, and urban growth.

Keywords
Housing, prices, construction, globalization

THE CONSTRUCTION INDUSTRY AND THE HOUSING MARKET

Construction industry has specific peculiarities that shape up the structure and operation of the market. The final product consists on an infrastructure built in a tangible location. Therefore, the activity is carried out in the same place where the product will be unavoidably immobile; this implies the spatial dispersion of the productive process. The product is unique, as a consequence of a specific contract that has a beginning and an end. There are physical variables that condition the productive process: geography, geology, use of natural materials, local weather, urban planning, etc. There are diverse alternative productive processes, and most of them are not susceptible to mechanization.

It is accepted a major division in construction industry between building and civil work. The former includes most of the industry, around two thirds of it, depending on the country. New residential and non-residential buildings (commercial, industrial, governmental, etc.), and renovation and maintenance of buildings are included.

The dynamic among the actors in construction industry is influenced by the national regulatory context. It includes [Winch (2000)]: legal system, zoning regulations, construction procedures, labor market rules, and procurement policies of each country. The client may be a public agency or a private promoter. Generally, the public agency promotes civil works, whereas the private client promotes buildings. Of course, this generalization is not always true; sometimes public clients promote buildings (public health, educational, administrative, etc.) and private clients promote urban developments. Legal system and procurement policies affect mainly public works (construction promoted by public agencies), whereas zoning and labor market regulations affect private clients.

Real estate (or property) market is the economic environment where land (legalized or not) and buildings can be sold or purchased according to the rules of liberalism and the regulations of each country. If we consider only residential buildings, we may call it “housing market”; that is the expression that we are going to use from now on. Property developers and real estate agencies generate the demand, being families the final consumers. In the Spanish housing system there is a strong prevalence for owning rather than renting property; European trends go in the same direction.

According to Alcaide *et al.* (1982), the main characteristics of the housing market are:

- Two sub-markets co-exist: consumption (housing services) and investment market (building).
- Housing is a heterogeneous product, from the point of view of the quality and the quantity.
- Final products are immobiles, thus each metropolitan area constitutes an independent market.
- Prices can not be compared to each other easily, therefore the market is quite imperfect.
- Supply can not be modified easily, because construction of new units takes time and it depends on the stock.
- Supply and demand respond slowly, since they operate with important time retards. There is a time delay from taking the decision to the effective supply of new units. Time is needed to buy land, legalize it, and urbanize it; and additional time is required for design housings, build them, and commercialize them. Demand reaction to changes in rent, prices, credits, etc., is also slow because moving households is difficult and expensive.
- Purchasing depends on credit to finance the property acquisition, because paying-offs and interests are linked to the transaction.
- Housing market deals not only with buying, but also renting.
- Public sector may exercise some kind of control on the property market: legal policies, zoning regulations, subsidized housing, etc.

Residential building represents one third of the total Spanish construction industry, whereas civil works (24%), building renovation and maintenance (25%) and non residential building (18%), complete the whole. In 2004, 687,000 new more units were built in Spain. That represents 6% of the Gross Domestic Product (GDP) and 19% of the Gross Fixed Capital Formation (GFCF). 10% of new residential homes were financially subsidized by state or regional governments. Housing value supposes around two thirds of the total families' wealth and it is a guarantee to one third of the total assets of banks and credit unions. On the other hand, consumption and investment in housing are 58% and 7% of Spanish GDP, respectively [SEOPAN (2005)].

Nevertheless, the most remarkable data are the evolution of prices in the Spanish housing market during last years. From 1976, the price has been multiplied by sixteen, nominally, and by two, actually. Internationally, Spain would be one of the three countries of the Organization for the Economic Co-operation and Development with long term higher growth of housing prices. Recently, the evolution is also remarkable with an actual growth of 55% from 1998 to 2002 [Martínez and Maza (2003)].

Tourist areas affect housing market too. Spain is the second European country with the largest amount of visiting tourists: fifty millions per year. Of these, nearly one million have bought houses in Spain. 80% of them are Germans and British citizens [Kozak (2002), Ministerio de Economía y Hacienda (2003)].

METHODOLOGY

Economic theory states that the balance between supply and demand is reached by the selling price of the product; that would only happen in a perfect market that it does not actually exist, specially when referring to the housing market. There are not explicit equations for explaining supply and demand relationships, and even if there were, the effects of the economic policies of each country and the interactions among countries affect them. Therefore, the first step in our methodology is to identify the most significant variables that induce the housing price. Later on, we will interrelate them using a correlation matrix that will show the relationships among the previously selected variables. From the analysis of the matrix, we can draw conclusions regarding the current situation of the Spanish housing market and, consequently, the impact of globalization on it.

In our analysis, housing price is the dependent variable (endogenous), whereas independent variables (exogenous) have to be chosen. In order to improve the selection of variables, we settle down, aprioristically, several groups of variables in such a way that allows us to choose the most important, depending on the results obtained from the data analysis. There are two groups of fundamental explanatory variables: supply and demand. Taking into consideration the imperfect operation of the housing market, these two are accompanied by other four groups of variables that supplement them: cost, income, financing, and environment (Table 1).

Table 1 Pre-selection of variables

Type	Group of variables
Dependent	1. Price
Independent	2. Supply
	3. Demand
	4. Costs
	5. Income
	6. Financing
	7. Environment

Although the investigation is focused on the Spanish housing market, we have to consider the significant influence of the European Union for the simple fact that the country belongs to a community with common economic and political objectives. Eleven of the countries of the Union are using the same currency: the Euro; they form the Euro zone. New adhesions (to the Union and to the Euro zone) are coming shortly. For this reason, the data search for group 7 (environment) is not made only for Spain, but also for the other fourteen countries that were part of the European Union in 2003; we call them EU15.

VARIABLES AND DATA

Thirty three variables were selected. They are displayed in Table 2, grouped in the seven categories previously established. The assigned code is shown too.

Table 2 Description of variables

Type	Group of variables	Concept	Code
Dependent	1. Price	Housing price per square meter	PPV
Independent	2. Supply	Building production	OPE
		Interior gross product	OPI
		Housings' stock	OSV
	3. Demand	Population growth	DCP
		Immigration flows	DFI
		Consumption prices ratio	DIP
		Stock exchange ratio (Madrid index)	DIB
		Number of divorces	DND
		Number of households	DNH
		Number of marriages	DNM
		Active population	DPA
		Unemployed population	DPP
		Employed population	DPO
	4. Cost	Cost of construction	CIC
		Cost of land	CPS
	5. Income	Labor wages in construction	RCL
		Interior gross product per capita	RPC
		Annual gross wage	RSA
	6. Financing	Interest rates for mortgage	FIH
		Inverse interest rates for mortgage	FII
	7. Environment (data from countries of the EU15)	Labor wages in construction	ECL
		Population growth	ECP
		Consumption prices ratio	EIP
		Cost of construction	EIE
		Number of divorces	END
		Number of households	ENH
		Number of marriages	ENM
		Unemployed population	EPP
		Housing price per square meter	EPV
		Interior gross product per capita	EPI
		Interest rates for mortgage	EIH
		Inverse interest rates for mortgage	EII

Spanish data, used in groups 1 to 6, were obtained from different sources: Banco de España (2005), Bolsas y Mercados Españoles (2005), Instituto Nacional de Estadística (2005a) (2005b), Martínez and Maza (2003), Ministerio de Economía y Hacienda (2005), Ministerio de Fomento (2001) (2004a) (2004b), and SEOPAN (2005). The Statistical Office of the European Commission (EUROSTAT) publishes harmonized data on each one of the countries of the European Union and Switzerland [European Commission (2004)]. Inside EUROSTAT, the BACH Project (Bank for the Accounts of Companies Harmonized) holds information of accounts from most of the European countries, United States, and Japan [EUROSTAT (2005)]. Additional data from the European Union were obtained from Ball (2005), European Central Bank (2005), and Trilla (2001).

We selected temporal series from year 1990 to year 2003. We have not included year 2004 because many data are not available yet. We have the additional problem of the multiple source of data, mainly for the different European countries, even though data are channeled through the EUROSTAT office. Although data are harmonized, the characteristics of each one of the countries are reflected in the data: construction industry, fiscal system, weather conditions, etc. We agree with Gujarati (2003), who affirms that "the results of the research are only as good as the quality of the data".

RESULTS

The coefficient of correlation measures the degree of association between two variables (or the sample co-variation between them). Some of its properties are [Gujarati (2003)]:

- It lies between the limits of –1 and +1.
- If the two variables are statistically independent, then the coefficient of correlation is zero; however, the opposite is not true.

Calculating each one of the coefficients, a correlation matrix was formed among the thirty three variables (Table 3). The statistical software used was SPSS (copyright SPSS Inc.).

Table 3 Correlation matrix

	PPV	OPE	OPI	OSV	DCP	DFI	DIP	DIB	DND	DNH	DNM	DPA	DPP	DPO	CIC	CPS	RCL	RPC	RSA	FIH	FII	ECL	ECP	EIP	EIE	END	ENH	ENM	EPP	EPV	EPI	EIH	EII
PPV	1.00	0.95	0.88	0.83	0.98	0.97	0.80	0.57	0.79	0.93	0.35	0.90	-0.75	0.94	0.80	0.95	0.78	0.87	0.80	-0.67	0.83	0.86	0.78	0.76	0.89	0.51	0.71	-0.58	-0.80	0.94	0.86	-0.69	0.78
OPE	0.95	1.00	0.98	0.95	0.96	0.91	0.92	0.77	0.91	0.97	0.24	0.98	-0.71	0.98	0.93	0.99	0.91	0.96	0.92	-0.84	0.92	0.96	0.91	0.90	0.97	0.68	0.87	-0.67	-0.85	1.00	0.97	-0.85	0.90
OPI	0.88	0.98	1.00	0.96	0.93	0.88	0.98	0.83	0.97	0.98	0.06	0.99	-0.56	0.93	0.98	0.98	0.97	0.99	0.98	-0.92	0.95	0.99	0.98	0.97	0.99	0.79	0.93	-0.79	-0.79	0.99	0.99	-0.93	0.94
OSV	0.83	0.95	0.96	1.00	0.86	0.80	0.92	0.90	0.93	0.92	0.20	0.97	-0.60	0.93	0.93	0.94	0.94	0.95	0.92	-0.91	0.95	0.96	0.93	0.91	0.93	0.82	0.92	-0.67	-0.79	0.96	0.96	-0.91	0.94
DCP	0.98	0.96	0.93	0.86	1.00	0.99	0.88	0.62	0.86	0.96	0.20	0.94	-0.63	0.92	0.87	0.97	0.85	0.92	0.88	-0.76	0.88	0.92	0.86	0.85	0.95	0.64	0.78	-0.71	-0.76	0.96	0.90	-0.77	0.83
DFI	0.97	0.91	0.88	0.80	0.99	1.00	0.82	0.54	0.82	0.92	0.20	0.89	-0.59	0.87	0.80	0.94	0.80	0.86	0.83	-0.70	0.85	0.86	0.81	0.79	0.91	0.59	0.71	-0.70	-0.69	0.91	0.84	-0.71	0.79
DIP	0.80	0.92	0.98	0.92	0.88	0.82	1.00	0.82	0.98	0.95	-0.12	0.97	-0.40	0.84	1.00	0.93	0.99	0.99	1.00	-0.96	0.93	0.98	1.00	1.00	0.98	0.85	0.96	-0.87	-0.72	0.94	0.98	-0.95	0.92
DIB	0.57	0.77	0.83	0.90	0.62	0.54	0.82	1.00	0.82	0.73	0.02	0.82	-0.43	0.75	0.84	0.77	0.87	0.82	0.82	-0.91	0.89	0.81	0.84	0.83	0.78	0.76	0.89	-0.59	-0.62	0.79	0.85	-0.93	0.93
DND	0.79	0.91	0.97	0.93	0.86	0.82	0.98	0.82	1.00	0.94	-0.08	0.96	-0.39	0.83	0.98	0.92	0.98	0.98	0.98	-0.96	0.93	0.98	0.98	0.98	0.97	0.85	0.95	-0.88	-0.69	0.93	0.97	-0.94	0.92
DNH	0.93	0.97	0.98	0.92	0.96	0.92	0.95	0.73	0.94	1.00	0.09	0.98	-0.57	0.92	0.95	0.98	0.93	0.98	0.95	-0.87	0.92	0.98	0.95	0.94	0.99	0.73	0.89	-0.78	-0.79	0.98	0.97	-0.86	0.89
DNM	0.35	0.24	0.06	0.20	0.20	0.20	-0.12	0.02	-0.08	0.09	1.00	0.10	-0.76	0.40	-0.10	0.17	-0.11	0.01	-0.13	0.18	0.08	0.04	-0.13	-0.17	0.01	-0.24	-0.12	0.45	-0.45	0.20	0.05	0.13	0.04
DPA	0.90	0.98	0.99	0.97	0.94	0.89	0.97	0.82	0.96	0.98	0.10	1.00	-0.58	0.94	0.97	0.98	0.96	0.99	0.97	-0.91	0.95	0.99	0.97	0.95	0.99	0.79	0.92	-0.77	-0.79	0.99	0.99	-0.91	0.94
DPP	-0.75	-0.71	-0.56	-0.60	-0.63	-0.59	-0.40	-0.43	-0.39	-0.57	-0.76	-0.58	1.00	-0.83	-0.42	-0.64	-0.39	-0.52	-0.40	0.30	-0.51	-0.51	-0.38	-0.35	-0.51	-0.07	-0.38	-0.02	0.79	-0.67	-0.55	0.36	-0.50
DPO	0.94	0.98	0.93	0.93	0.92	0.87	0.84	0.75	0.83	0.92	0.40	0.94	-0.83	1.00	0.85	0.95	0.83	0.90	0.84	-0.76	0.88	0.90	0.83	0.81	0.90	0.57	0.79	-0.52	-0.88	0.97	0.92	-0.78	0.86
CIC	0.80	0.93	0.98	0.93	0.87	0.80	1.00	0.84	0.98	0.95	-0.10	0.97	-0.42	0.85	1.00	0.93	0.99	0.99	1.00	-0.96	0.92	0.98	1.00	1.00	0.98	0.85	0.96	-0.85	-0.73	0.94	0.99	-0.95	0.92
CPS	0.95	0.99	0.98	0.94	0.97	0.94	0.93	0.77	0.92	0.98	0.17	0.98	-0.64	0.95	0.93	1.00	0.92	0.97	0.93	-0.86	0.95	0.96	0.93	0.91	0.98	0.72	0.87	-0.72	-0.79	0.99	0.96	-0.87	0.92
RCL	0.78	0.91	0.97	0.94	0.85	0.80	0.99	0.87	0.98	0.93	-0.11	0.96	-0.39	0.83	0.99	0.92	1.00	0.98	0.99	-0.98	0.95	0.97	1.00	0.99	0.97	0.87	0.96	-0.87	-0.70	0.93	0.98	-0.97	0.95
RPC	0.87	0.96	0.99	0.95	0.92	0.86	0.99	0.82	0.98	0.98	0.01	0.99	-0.52	0.90	0.99	0.97	0.98	1.00	0.99	-0.93	0.94	0.99	0.98	0.98	0.99	0.80	0.95	-0.82	-0.79	0.98	1.00	-0.94	0.94
RSA	0.80	0.92	0.98	0.92	0.88	0.83	1.00	0.82	0.98	0.95	-0.13	0.97	-0.40	0.84	1.00	0.93	0.99	0.99	1.00	-0.96	0.93	0.98	1.00	1.00	0.98	0.84	0.96	-0.87	-0.71	0.94	0.98	-0.95	0.93
FIH	-0.67	-0.84	-0.92	-0.91	-0.76	-0.70	-0.96	-0.91	-0.96	-0.87	0.18	-0.91	0.30	-0.76	-0.96	-0.86	-0.98	-0.93	-0.96	1.00	-0.94	-0.93	-0.97	-0.96	-0.91	-0.88	-0.95	0.84	0.60	-0.87	-0.93	0.98	-0.94
FII	0.83	0.92	0.95	0.95	0.88	0.85	0.93	0.89	0.93	0.92	0.08	0.95	-0.51	0.88	0.92	0.95	0.95	0.94	0.93	-0.94	1.00	0.94	0.94	0.92	0.94	0.80	0.90	-0.75	-0.68	0.94	0.94	-0.94	0.98
ECL	0.86	0.96	0.99	0.96	0.92	0.86	0.98	0.81	0.98	0.98	0.04	0.99	-0.51	0.90	0.98	0.96	0.97	0.99	0.98	-0.93	0.94	1.00	0.98	0.97	0.99	0.82	0.95	-0.81	-0.79	0.97	0.99	-0.92	0.92
ECP	0.78	0.91	0.98	0.93	0.86	0.81	1.00	0.84	0.98	0.95	-0.13	0.97	-0.38	0.83	1.00	0.93	1.00	0.98	1.00	-0.97	0.94	0.98	1.00	1.00	0.98	0.87	0.97	-0.87	-0.70	0.93	0.98	-0.96	0.94
EIP	0.76	0.90	0.97	0.91	0.85	0.79	1.00	0.83	0.98	0.94	-0.17	0.95	-0.35	0.81	1.00	0.91	0.99	0.98	1.00	-0.96	0.92	0.97	1.00	1.00	0.97	0.86	0.96	-0.89	-0.69	0.92	0.97	-0.96	0.92
EIE	0.89	0.97	0.99	0.93	0.95	0.91	0.98	0.78	0.97	0.99	0.01	0.99	-0.51	0.90	0.98	0.98	0.97	0.99	0.98	-0.91	0.94	0.99	0.98	0.97	1.00	0.79	0.92	-0.83	-0.76	0.98	0.98	-0.91	0.92
END	0.51	0.68	0.79	0.82	0.64	0.59	0.85	0.76	0.85	0.73	-0.24	0.79	-0.07	0.57	0.85	0.72	0.87	0.80	0.84	-0.88	0.80	0.82	0.87	0.86	0.79	1.00	0.82	-0.80	-0.46	0.71	0.78	-0.82	0.78
ENH	0.71	0.87	0.93	0.92	0.78	0.71	0.96	0.89	0.95	0.89	-0.12	0.92	-0.38	0.79	0.96	0.87	0.96	0.95	0.96	-0.95	0.90	0.95	0.97	0.96	0.92	0.82	1.00	-0.80	-0.69	0.89	0.95	-0.97	0.94
ENM	-0.58	-0.67	-0.79	-0.67	-0.71	-0.70	-0.87	-0.59	-0.88	-0.78	0.45	-0.77	-0.02	-0.52	-0.85	-0.72	-0.87	-0.82	-0.87	0.84	-0.75	-0.81	-0.87	-0.89	-0.83	-0.80	-0.80	1.00	0.39	-0.70	-0.78	0.81	-0.74
EPP	-0.80	-0.85	-0.79	-0.79	-0.76	-0.69	-0.72	-0.62	-0.69	-0.79	-0.45	-0.79	0.79	-0.88	-0.73	-0.79	-0.70	-0.79	-0.71	0.60	-0.68	-0.79	-0.70	-0.69	-0.76	-0.46	-0.69	0.39	1.00	-0.84	-0.81	0.65	-0.70
EPV	0.94	1.00	0.99	0.96	0.96	0.91	0.94	0.79	0.93	0.98	0.20	0.99	-0.67	0.97	0.94	0.99	0.93	0.98	0.94	-0.87	0.94	0.97	0.93	0.92	0.98	0.71	0.89	-0.70	-0.84	1.00	0.98	-0.88	0.92
EPI	0.86	0.97	0.99	0.96	0.90	0.84	0.98	0.85	0.97	0.97	0.05	0.99	-0.55	0.92	0.99	0.96	0.98	1.00	0.98	-0.93	0.94	0.99	0.98	0.97	0.98	0.78	0.95	-0.78	-0.81	0.98	1.00	-0.94	0.94
EIH	-0.69	-0.85	-0.93	-0.91	-0.77	-0.71	-0.95	-0.93	-0.94	-0.86	0.13	-0.91	0.36	-0.78	-0.95	-0.87	-0.97	-0.94	-0.95	0.98	-0.94	-0.92	-0.96	-0.96	-0.91	-0.82	-0.97	0.81	0.65	-0.88	-0.94	1.00	-0.98
EII	0.78	0.90	0.94	0.94	0.83	0.79	0.92	0.93	0.92	0.89	0.04	0.94	-0.50	0.86	0.92	0.92	0.95	0.94	0.93	-0.94	0.98	0.92	0.94	0.92	0.92	0.78	0.94	-0.74	-0.70	0.92	0.94	-0.98	1.00

Even though correlation does not imply causality; causality demands correlation. In our case, the causality derives from the behavior of the explanatory variables related to the economic model of supply and demand. It is not possible to apply Granger's causality test [Granger and Newbold (1976)], provided that we are not trying to carry out predictions of time series [Pulido (2003)].

DISCUSSION AND CONCLUSIONS

Housing price is explained, basically, by the variables chosen in Table 4. Among the variables of the same group the multicolinearity makes them incompatible to each other. Hence, only one of them is selected per group of variables: always the one with highest coefficient of correlation.

Table 4 Selected variables per group and coefficient of correlation

Type	Group of variables	Concept	Code	Coefficient
Dependent	1. Price	Housing price per square meter	PPV	1.00
Independent	2. Supply	Building production	OPE	0.95
	3. Demand	Population growth	DCP	0.98
	4. Costs	Cost of land	CPS	0.95
	5. Income	Interior gross product per capita	RPC	0.87
	6. Financing	Inverse interest rates for mortgage	FII	0.83
	7. Environment (EU15)	Housing price per square meter	EPV	0.94

Population growth, cost of land, and building production are the variables that have better coefficients, as it was expected. Housing price per square meter in the European Union has a very good coefficient; almost as good as the previously mentioned. Finally, interior gross product per capita and inverse interest rates for mortgage have coefficients higher than 0.80; that can be considered good enough.

More production in building construction stands for higher quantity of construction materials, more machinery, and more workers. If these are scarce, the price will increase and, consequently, the costs and the final price of the product will raise too. Linked to the supply group is the housings' stock that has a significant influence on the prices; the stock can act as an important yield between supply and demand.

The population boom of the sixties and seventies, and a more recent migratory flow (from South America, North Africa and East Europe) are demanding new homes. Changes in family structure (increment of divorces and families of one member, lengthening of life, etc.) have increased the number of households too. Population growth means augmenting demand of housing and, depending on the supply's elasticity of the product, the prices may go up or not. Anyway, in housing market, the supply is rigid, due to the time elapsed from purchasing the land to commercialize the building; certainly, the immobility of the product affects the supply too. Therefore, prices increase with more demand, because of this non-existent synchronization between supply and demand.

Another significant variable of the same group (demand) is the employed population. Families feel secure enough for purchasing a new home when some of the members are employed. This situation gives the families the stability they need to ask a bank for credit.

Land is very important. It is the raw material where the building is going to be placed. Furthermore, land has to be legalized and urbanized according to state and local regulations. In many metropolitan areas the land that can be legalized is scarce, thus prices go up.

Rates of interest measure the opportunity cost of any investment. The current low rates, and the extension of paying-off terms, empower the families for more capacity of payment, hence, more purchases, not only housing but also many other assets. This situation favors an increase of prices. Some investors use the housing market as an alternative for investment, because other choices (i.e. stock exchange market) do not give the good results that they used to. In any case, the dropping off of rates may enlighten the raising price of housing, maybe in the same proportion than the diminution of interest rates.

In time, the European Union will match the levels of the citizens' life and the economies of the states members. Nowadays, the EU15 average housing price per square meter is still higher than the Spanish one. On the other hand, the growth of housing prices is higher than in EU15 countries because the Spanish reference level was very low. It is expected that the price keeps on raising till it reaches the average price of the western European countries, specially the eleven ones that have a unified currency (the Euro) since 2002: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. All of them, but Ireland and Portugal, have higher standard of life than Spain.

In consequence, housings prices have augmented, and they will continue augmenting, because a growing demand exists. Basically, our analysis shows that the increment of the housing prices is based on:

- An increase of population and migratory flows, and changes in family structure.
- A convergence process among rent levels (increasing), interest rates (low), and favorable financing terms (i.e. long paying-off terms) that allow more families to assume the payment of a mortgage.
- The decreasing profitability of other alternative markets (i.e. stock exchange market).
- The strong impulse of demand of second homes.
- Belonging to an economic and political group as the European Union whose average income per capita (EU15) is higher than the Spanish one.

It is also very remarkable the derived effect of the involvement of Spain in the European Union, and specifically to the Euro zone. The common currency tends to standardize the economy of all countries. This affects the housing prices too, in spite of the immobility of the product and the behavior of each micro-market (i.e. metropolitan area). We have to keep in mind that the product can not move, but people can. Some of them tend to buy a second home in a tourist area (and most of the Spanish coast is) whenever they are able to invest.

The number of foreign residents setting up homes in Spain is increasing. For them the housing prices are still cheap, even though for Spanish citizens are too expensive. It is not only the pensioners who are looking at setting up homes abroad, but also many young families are leaving their native countries to go abroad and work at home in their new country of residence, thanks to the easy access to current information and communication technologies. Many foreign investors from mature domestic markets are coming to Spain to obtain the expected returns, particularly in the buy-to-let sector.

Spain still may be considered a developing economy. Its macro-economic ratios are far from United States, Japan, Germany, Britain, or France. Nevertheless, its economic growth in the last ten years is 50% higher than the average of the countries of the Euro zone. For Spain, even for Ireland and Portugal, the European Union has been a very positive bet, and the expectations for the future are good.

The Euro zone is a test for the future of humankind: eleven countries, with different laws, history, culture, language, etc., join together to share a common currency. This is affecting the economies of these countries more deeply than the European Union itself for the other fourteen countries that do not take part of the Euro zone. This is a real economic globalization taken to a micro level. The consequences can be observed daily: standardization and leveling is happening smoothly. Housing market is only one of the sectors affected. Economic globalization influences the housing prices evolution in each country through financial markets, migratory and tourist movements, and urban growth, among others.

In the near future more European countries will join the Euro zone and this economic micro-globalization will expand radically. This experiment should be an example for other developing countries in other parts of the world (i.e. MercoSur); therefore barriers among countries may disappear and communities may get closer. Maybe then, globalization will be a concept with positive connotations for developing economies.

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A Comparative Study of Market Structure in the Chinese Construction Industry

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Abstract:
The Chinese construction industry has developed over the past two decades within the framework of a socialist market system. Nevertheless, the poor industry performance indicates an inefficient and ineffective market. This study investigates the market structure of the Chinese construction industry in terms of firm size distribution, the Lorenz Curve and the associated Gini coefficient, and the proportion of specialty contractors, and the results for the Chinese construction industry are compared with those for the United States, United Kingdom, and Japan. This comparative analysis indicates that the current market structure in the Chinese construction industry is inappropriate for its further development, and this is an important factor contributing to its poor performance. Chinese firms are generally much larger than firms in developed countries, and they are quite similar among themselves in terms of business volume and services provided. Stated alternately, the Chinese market is not as fragmented as other construction markets. Because of their similarity, many comparable contractors compete with each other in the market, leading to fierce rivalry. The high barriers for firms to exit from the industry make the situation even worse. Several policies are suggested for the government to improve the development of the Chinese construction market.

Keywords
Market structure, comparative analysis, chinese construction industry, firm size distribution, specialty contractors

INTRODUCTION

Ever since China launched its far-reaching reform of its national economic system in 1978, there has been a process of transformation from a centrally planned economy to a socialist market economy (Flanagan and Li, 1997; Chan et al. 1999; Han and Ofori, 2001). The Chinese construction industry was one of the first industries in the nation to be reformed. The goal of the industry-wide reform was to shift from the old assignment system to a system in which the survival of a construction business is determined by the competitive market. As a result of reduced central control over state-owned enterprises and the introduction of competition and incentives for people to make and share in profits, the Chinese construction industry has been growing rapidly (Flanagan and Li, 1997).

Nevertheless, despite the industry's great achievements, such as a high annual growth rate and an increasing contribution to the GDP, its development over the past decade or so suggests that it faces serious difficulties during its transition to a market-oriented system. In particular, the profit rate declined during the transformation and has now reached low levels. The percentage of unprofitable firms in the industry has been rising since the early 1990s and remains high today. Furthermore, construction firms compete fiercely in a market that is not fully developed and remains quite different in structure from that seen in well-established market economies.

METHODOLOGY

Market structure determines the degree of competition and is a major determinant in the behavior and performance of firms (Carlton and Perloff, 1994). Therefore, the analysis of market structure is the first step towards a study of the industry. The structure of the market is defined in terms of the number and size distribution of competing firms (Bain, 1968). In this study, the details of which have been addressed more comprehensively by Wang(2004), the market structure is examined in terms of firm size distribution by employment, the Lorenz Curve, and the associated Gini coefficient, and the results for the Chinese construction industry are compared with those for the US, UK, and Japan. In addition, issues of specialty contractors and subcontracting, as well as conditions of market entry and exit, that affect the market structure in the Chinese construction industry are investigated. China has been switching to a global market economy and the Chinese construction market has been adopting common international practices. China's entry into the World Trade Organization is accelerating the transformation process. Comparison with the well established American, British, and Japanese construction markets will assist in understanding the practices that could help the future development of the Chinese construction industry in this transitional period.

FIRM SIZE DISTRIBUTION BY EMPLOYMENT

The size distributions of contractors by employment size class in the US, UK, and Japan have the following characteristics (see Tables A1 to A4 in the Appendix):

(a) The number of contractors is large in these developed countries. In the US, there were 656,448 construction establishments in 1997 (Construction statistics in the US are based on establishments, rather than firms, and one firm may be comprised of multiple establishments. However, the vast majority of US construction firms are small and localized, there were more than half a million construction firms in the United States (Barrie and Paulson, 1992)). In the UK in 2000, there were 163,426 construction firms. The size of the Japanese construction industry is similar to that in the US. In 1996, there were 647,356 construction establishments in Japan.

(b) Most contactors are very small. More than 90% of all contractors in the US had fewer than 20 employees. About 98% of the total construction firms in the UK had fewer than 24 employees. In Japan, about 95% of the total contractors had fewer than 20 employees.

(c) The average size is less than 10 employees per construction establishment or firm.

(d) Large builders have a market share advantage over the small ones. Less than 1% of the total contractors in the US had more than 100 employees, but they represented about 27% of the total output. There were 518 firms that had over 115 employees in the UK; although accounting only for 0.32% of all contractors, these firms accomplished more than one-third of the total output. The largest firm group in Japan made up only 0.06% of all contractors, but produced 23% of all output.

Unlike the three well-developed market economies, the Chinese construction statistics do not categorize construction firms by employment size. Instead, China publishes construction statistics based on a qualification class system that was established by the Ministry of Construction. Table 1 shows the number of firms, gross output value, employment, and average employees per firm for each qualification class in the Chinese construction industry in 2000. Qualification Class One was the highest class and its holders usually have thousands of employees. The size of the construction firms in the lower qualification classes is smaller to varying degrees, depending on the class. In general, higher qualification class firms employ more people than lower class firms. Therefore, qualification class is used to classify construction firms to analyze the size distribution of firms in the Chinese construction industry, assuming that higher class firms are larger than lower class firms in terms of the number of employees, and Qualification Class Four firms are larger than firms without a qualification class.

Table 1. Employment Size Distribution of Contractors by Qualification Class in China, 2000

Qualification class	Contractors			Output			Total employment (1,000)	Average employees per firm
	Number of firms	Percentage of total (%)	Cumulative percentage (%)	Output (billion RMB)	Percentage of total (%)	Cumulative percentage (%)		
Without	49,745	51.14	51.14	428.34	25.53	25.53	6,434.7	129.4
Class	17,562	18.06	69.20	104.88	6.25	31.78	2,870.1	163.4
Class	19,228	19.77	88.97	249.89	14.89	46.67	5,844.1	303.9
Class	8,307	8.54	97.51	347.29	20.70	67.36	6,321.1	760.9
Class	2,421	2.49	100	547.69	32.64	100	5,939.0	2453.1
Total	97,263	100	-	1678.0	-	-	27,409.0	281.8

Source: State Statistic Bureau (2001): *China Statistical Yearbook*; State Statistical Bureau (2001): China Statistical Yearbook on Construction

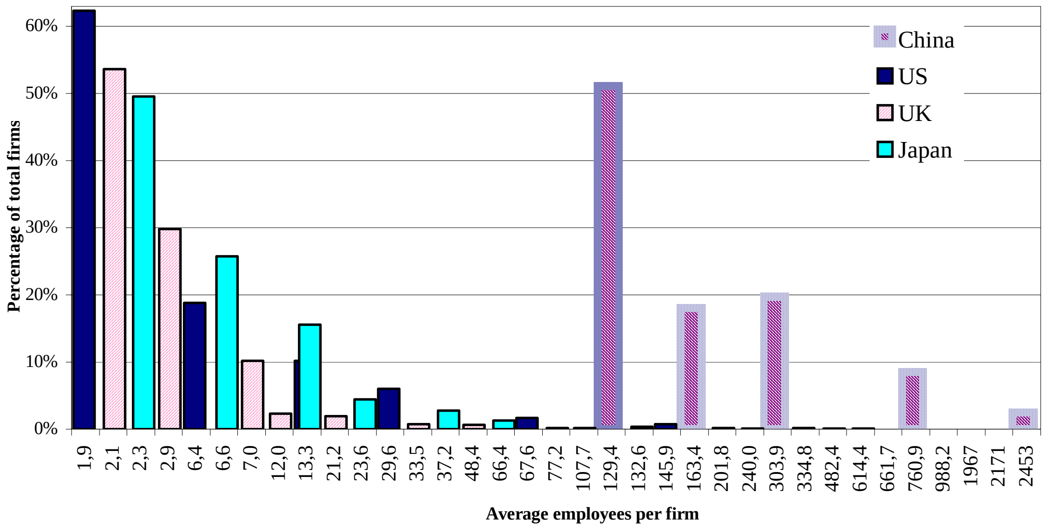
Compared to the three developed countries, there are far fewer construction firms in China, the firm size is much larger, and a big difference exists between the firm size distribution in China and the other countries. In 2000, there were 97,263 Chinese construction firms. The average number of employees per firms was 282, about 30 times that of the US and Japan and 50 times that of the UK. In addition, the larger contractors in China produced a smaller percentage of the total output than their counterparts in the well-developed countries. Class One firms that averaged 2453 employees per firm accounted for 2.5% of the total firms and one-third of the total output.

Since employment size is classified differently for each of the four countries, the average number of employees per firm for each firm size and the measure of this firm size as a percentage of all contractors are used in Figure 1 to compare in one column chart the approximate firm size distributions by employment for the four countries (see Table 1 and Tables A1 to A3 in the Appendix for the source data).

Figure 1 demonstrates clearly the characteristics of construction firm size distributions in China and the other three countries. As can be seen, the distributions are similar in the US, UK, and Japan; most of contractors are very small, the range of firm sizes is very wide, and the number of contractors decreases drastically when firm employment size increases. The contractors in the three countries that have more than 20 people account for less than 10% of total. The proportion of the contractors that employ more than 100 people is less than 1%. In contrast, most construction firms in China have more than 100 employees. The range of firm size is narrower, and the distribution is much more even than in the three developed countries. This indicates that Chinese contractors are more similar with a higher proportion of larger firms.

Based on the above analysis, the size of Chinese contractors is seen to be much larger than those in developed countries and the overall distribution of the number of firms is much more biased toward medium and large firms, although medium and large firms account for a smaller percentage of the overall construction work.

Figure 1. Size Distributions of Construction Firms By Employment (Wang, 2004)

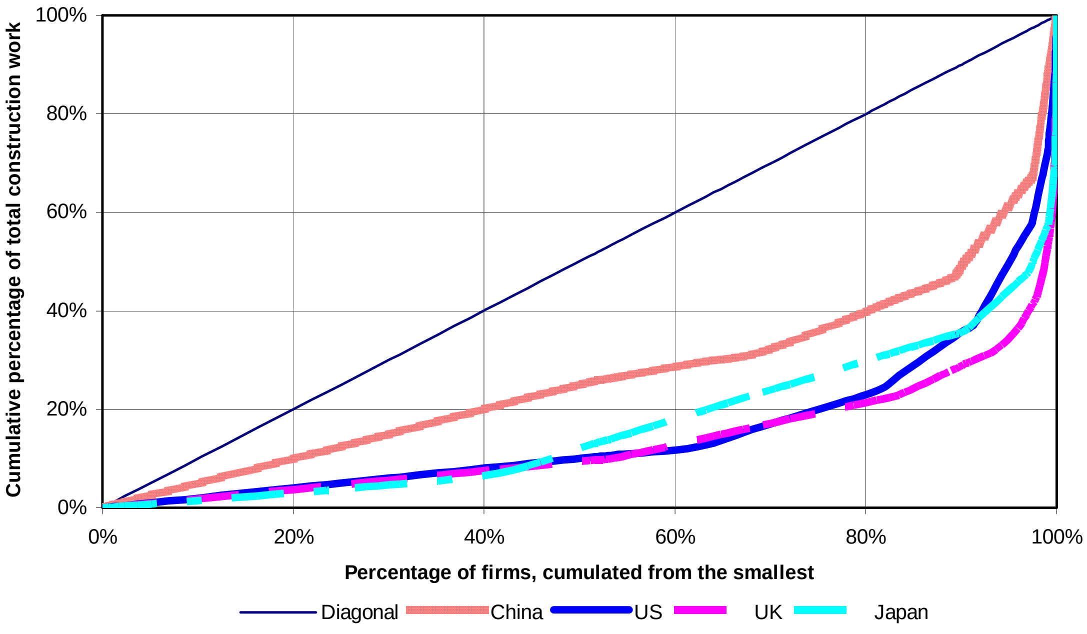


LORENZ CURVE AND GINI COEFFICIENT

The Lorenz curve and its associated Gini coefficient indicate the degree of competition in a market by measuring inequality in the size distribution of firms (Hart and Prais, 1956). The Gini coefficient is a statistical measure derived from the Lorenz curve, which relates the cumulative share of the total value of any variable (output, revenue, number of employees, etc.) to the number or percentage of firms in the industry arranged in increasing size. If the "curve" is a straight line, all firms are of equal size. A diagonal would suggest that all the firms are of equal size and the industry may be viewed as completely unconcentrated, indicating fierce competition in the market. In general, however, firms are not of equal size in any given industry and the greater the deviation of the Lorenz curve from the diagonal, the greater the inequality in firm sizes and the higher the market concentration. Alternatively, the closer to the diagonal, the more evenly distributed and more unconcentrated are the firms. The Gini coefficient is defined as the ratio of the area between the diagonal and the actual curve to the area of the total triangle beneath the diagonal. Its maximum and minimum values are one and zero, representing total inequality and total equality, respectively.

The Lorenz curves in Figure 2 illustrate the size distributions of the construction firms in terms of the construction value in the four countries (see Table 1 and Tables A1, A2, and A4 in the Appendix for the source data). The horizontal axis represents the percentage of all contractors cumulated from small to large, while the vertical axis represents the cumulative share of the total value of construction work for the contractors in the four countries. The diagonal line represents equality in the size distribution. Figure 2 shows clearly that the Lorenz curve of Chinese contractors is much closer to the diagonal than the other three curves. The Gini coefficient for Chinese contractors is 0.47, while the Gini coefficients for the US, UK, and Japan are 0.70, 0.74, and 0.67, respectively. The Lorenz curves for the US, UK, and Japan are nearly congruent, deviating much farther from the diagonal, and rising steeply near the end of the curve. The figure shows that most contractors are small and that inequality in firm size is greater in the three developed countries. By contrast, the size of the Chinese contractors is more equally distributed. In China, the small contractors are relatively bigger and the large ones are relatively smaller in terms of production. The more equal size distribution in China indicates that (a) the market is less concentrated compared with the US, UK, and Japan and (b) there are many comparable construction firms competing, implying intense competition in the market.

Figure 2. Lorenz Curves of Contractors in China, the US, UK, and Japan(Wang, 2004)



SPECIALTY CONTRACTORS AND SUBCONTRACTING

Specialty contractors and subcontracting, which has benefited construction by utilizing the work force more efficiently, increasing labor productivity, and promoting the use of new materials, methods, equipment, and so forth, is the result of the development of the construction industry. With advancing technology and improved equipment and materials, construction projects become more complex and the scope of these projects requires a tremendous work force of trade specialists in many disciplines. Few companies could keep a large work force steadily employed year-round. As a result, the general contractor dispensed a large work force and parceled out most of this type of work to specialty contractors. Specialty contractors, whose output is usually only a part of the entire as-built product, typically enter the contracting system as subcontractors. Subcontractors can keep themselves fully employed by working for several builders. Furthermore, the subcontractor has the special training and experience to evaluate and supervise the work of a particular trade most effectively, a skill not necessarily possessed by the builder. Hence, the subcontracting system contributes to the economical utilization of those skills used infrequently by each of many builders.

In developed construction markets, the majority of construction work is subcontracted to subcontractors (Hillebrandt, 2000). There is a large number of specialty firms in the industry, and most of them are very small. According to the U.S. Census Bureau (2000), 63% of all contractors were specialty trade contractors in the industry in 1997. The average size of a specialty trade contractor is about 8 employees. Specialty trades include plumbing, heating and air conditioning, carpentry, concrete work, painting and paper hanging, electrical work, etc. In the UK there were 163,426 firms in the industry in 2000, and 63% of them were specialist trade contractors (Department of Trade and Industry, 2001). The average size of a specialist trade contractor is about 5 employees. Specialist trade contractors in the UK are similar to specialty trade contractors in the US. In Japan, specialty trade contractors accounted for about 70% of the total firms in the industry in 2003 (Ministry of Land, Infrastructure and Transport, 2004).

The current contracting practice came to the Chinese construction industry in the early 1980s when a competitive bidding system was introduced into the industry. Under the former planning system, the government assigned projects to construction firms that were accessories to government organizations. Most Chinese firms were large and established to provide comprehensive services, including laborers in a range of specialties. During the reform, Chinese firms have been transforming to individual business entities similar to typical firms in developed countries. However, the contracting system in China is underdeveloped, and the current construction market structure, affected by the former system, is not as fragmented and specialized as in developed markets. In fact, the majority of firms compete in the general contracting market, and they only go to the subcontracting market when they have no alternatives. The number of specialty contractors in China is small and their development is ignored. In 2000, specialty contractors accounted for 26% of the total construction firms (State Statistical Bureau: *China Statistical Yearbook on Construction*, 2001). Furthermore, there are currently many restraints on subcontracting, which hinder the development of the number, quality, and size of specialty firms. For example, the People’s Republic of China Construction Law stipulates that a general contractor must finish the principal part of the project and he may only subcontract minor and unimportant work to subcontractors. A given subcontractor is not allowed to further subcontract his work. Because of their inferior position in the industry, specialty firms often have to accept harsh and unfair contract terms. The small number of specialty firms is one of the important reasons that the number of small firms in China is low.

MARKET ENTRY AND EXIT

Ease of entry and exit is important in determining market structure and the subsequent performance of firms (Carlton and Perloff, 1994). Firms will tend to enter the market if they think they can make at least normal profits in the market. The entry of new firms produces competition that acts quickly to reduce prices and profits. Meanwhile, a firm will leave the industry if it is not making normal profits. Construction is thought to have easy entry and exit (Buzzelli, 2001). In the construction markets in the US, UK, and Japan, entry barriers (including absolute cost advantage, economies of scale, and product differentiation) and the cost incurred by a firm to exit the industry are generally low, especially when compared with the production factors needed in other industries.

In contrast, while the overall barrier for entry into the construction market is low in China, the barriers for Chinese firms to exit the industry are high. The major barriers include settlement costs, debt, social responsibility, and government regulations and intervention. Chinese construction firms, especially state-owned firms, are responsible for arranging for their employees if they exit the industry, leading to significant settlement costs. The debt ratio for most Chinese firms is high, so firms cannot easily exit the market. Furthermore, firms' social responsibility, such as the burden of retired employees, makes it difficult for firms to exit. Moreover, government organizations sometimes are reluctant to support the exit of state-owned firms, because the firms offer necessary benefits and local stability. Finally, firms are limited from using bankruptcy and other forms of liquidation to exit from the market because of the underdeveloped laws and relevant facilities. Many inefficient firms have to stay in the industry and continue to bear a heavy burden of debt, social responsibility, and loss. Due to their lack of competitiveness, these firms tend to secure projects by cutting price and other abnormal means of competition, thus disrupting the order of the market and lowering the industry performance.

DISCUSSIONS

The nature of construction projects and the construction process encourages a pyramidal distribution for firm size (Li et al. 2001). The contracting aspect of production involves many disciplines, which result in the assembly of a large variety of materials and components. The structure of the construction industry is highly specialized and layered with a few large contractors that have advantages of capital, technology, and management skills, and these provide comprehensive service at the top of the pyramid. A large number of small contractors that have functional flexibility and generally a high degree of specialization form the bottom. Due to the variety of different size construction projects and the abundant opportunities for subcontractors with different specializations, the market is fragmented in such a way that different segments sustain firms of different sizes. Much distinguishes small, medium, and large firms from each other in terms of gross output, employment size, and services. Small, medium, and large firms all have an important role to play in an integrated construction system. Normally a small number of large firms serve as a general contractor on large or complex projects in national or global markets, while small and medium-sized contractors, many of whom have specialized trade expertise, serve as subcontractors or undertake small projects in local markets. Instead of competing actively with each other, small, medium, and large contractors complement each other and cooperate among themselves on construction projects.

The foregoing study demonstrates a similar pyramidal pattern in construction firm size distributions in the US, UK, and Japan. There is a large number of contractors in the construction market. Small contractors dominate in number, and there are only a few large contractors. The difference between firms of small and large size is significant. Furthermore, there is a large proportion of specialty firms in the industry. Firms of different sizes have their own niches within the market. Moreover, firms enter and exit the market easily. The construction markets in these three countries are well established. Their market structures remain stable and their construction statistics in recent years confirm consistent firm size distributions and the proportions of contractors in various trades. This stability implies that the pattern of their market structures, shaped by long-term market development, is appropriate to the industry and is thereby efficient and effective.

In contrast, the market structure in the Chinese construction industry is still affected by the old system and is quite different from that in market-oriented countries. With fewer firms in the market, the industry is less concentrated, meaning that firms experience more intense competition. The Chinese firms are much larger in terms of employment and are quite similar in terms of size and the services they provide. The percentage of small firms is relatively low, thus causing a “trapezoidal” structure for the industry. However, these small firms are not “small” in terms of employment and they are not really specialized compared to the small firms in developed construction markets. The Chinese market is not as fragmented as other construction markets. Most Chinese firms are general contractors, regardless of size. Because of their similarity in size and services, many comparable contractors compete with each other in the market, leading to fierce rivalry. Meanwhile, new similar-scale entrants have largely concentrated in markets where the barriers to entry are very low (housing, in particular), intensifying market structure problems in the industry. The high barriers for Chinese firms to exit the industry make the situation even worse. Many inefficient firms have to stay in the industry and continue to bear a heavy burden of debt, social responsibility, and loss. Due to lack of competitiveness, these firms tend to secure projects by cutting price and other abnormal means of competition, thus disrupting the order of the market and lowering the industry performance.

CONCLUSIONS

This comparative analysis suggests that the current market structure in the Chinese construction industry is inappropriate to its further development, and this is an important factor for the poor industry performance. The Chinese construction market has been in a state of evolution for more than a decade. During this period it has been continually improving, increasingly accepting international practices, and moving in the direction of a mature construction market. With time, the market structure will undoubtedly evolve in the direction prevalent in the three mature construction markets. Because Chinese contractors have been exposed to the free market system only a short time ago, they are not yet strategically sophisticated and still depend on the government. Furthermore, because the market system is still developing and market mechanisms have not been functioning well in China, the Chinese government must promulgate effective industrial policies to improve market structure to enhance the performance of the construction industry. This is necessary for the healthy development of the market and industry, especially throughout this transition period, and it is imperative because of China's entry into the World Trade Organization.

Suggested industrial policies for the government to enhance further development in the Chinese construction market include (a) support and develop specialty firms by reducing the restraints on subcontracting and extending the subcontracting scope and encouraging the rapid development of specialty firms by transforming or disintegrating existing contractors in further enterprise reform programs; (b) improve management of the qualification class system by establishing limits for the scope of different qualification classes to encourage firms of different sizes to work in their niches within the market; (c) develop small firms by establishing specific organizations to serve small firms; (d) foster and develop the largest firms by supporting them with capital; and (e) facilitate the exit of unprofitable firms from the industry.

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APPENDIX

Table A1. Employment Size Distribution of Contractors in the US, 1997

Size class	Contractors			Value of construction work			Total employ ment (1,000)	Average employees per firm
	Numbera	Percent age of total (%)	Cumulative percentage (%)	Value (million US$)	Percent age of total (%)	Cumulative percentage (%)		
1-4	409,256	62.34	62.34	105,143.9	12.44	12.44	762.2	1.9
5-9	123,389	18.80	81.14	95,321.2	11.27	23.71	789.9	6.4
10-19	67,093	10.22	91.36	116,063.8	13.73	37.44	890.5	13.3
20-49	39,806	6.06	97.42	173,513.9	20.52	57.96	1,179.1	29.6
50-99	10,958	1.67	99.09	124,349.2	14.71	72.66	741.3	67.6
100-249	4,717	0.72	99.81	125,648.2	14.86	87.52	688.2	145.9
250-499	914	0.14	99.95	55,121.6	6.52	94.04	306.0	334.8
500-999	242	0.04	99.99	31,044.4	3.67	97.71	160.1	661.7
1000and over	75	0.01	100.00	19,337.3	2.29	100.00	147.5	1967.1
Total	656,448	100	-	845,543.6	100	-	5,654.9	8.6

Source: U.S. Census Bureau (2000).
[a]This is the number of construction establishments in the US. A construction establishment is defined as a relatively permanent office or other place of business where the usual business activities related to construction are conducted.

Table A2. Employment Size Distribution of Contractors in the UK, 2000

Employment size class (employees)	Contractors			Value of construction work			Total employment (1,000)	Average employees per firm
	Number of firms	Percentage of total (%)	Cumulative percentage (%)	Value (million £)	Percentage of total (%)	Cumulative percentage (%)		
1	87,712	53.67	53.67	1,415.4	10.10	10.10	185.9	2.1
2-3	48,773	29.84	83.51	1,798.8	12.84	22.94	142.8	2.9
4-7	16,584	10.15	93.66	1,281.4	9.15	32.09	116.0	7.0
8-13	3,790	2.32	95.98	604.9	4.32	36.41	45.3	12.0
14-24	3,104	1.90	97.88	881.5	6.29	42.70	65.7	21.2
25-34	3,201	0.73	98.62	767.3	5.48	48.17	40.2	33.5
35-59	1,109	0.68	99.29	1,080.8	7.71	55.89	53.7	48.4
60-79	364	0.22	99.52	618.5	4.41	60.30	28.1	77.2
80-114	271	0.17	99.68	693.9	4.95	65.26	29.2	107.7
115-299	341	0.21	99.89	1,503.5	10.73	75.99	68.8	201.8
300-599	91	0.06	99.95	960.7	6.86	82.85	43.9	482.4
600-1199	51	0.03	99.98	1,280.0	9.14	91.98	50.4	988.2
1200and over	35	0.02	100.00	1,123.3	8.02	100.00	76.0	2171.4
Total	163,426	100	-	14,010.1	100	-	945.9	5.8

Source: Department of Trade and Industry (2001).

Table A3. Employment Size Distribution of Contractors in Japan, 1996

Employment size class (employees)	Contractors			Total employment (1,000)	Average employees per firm
	Number[a]	Percentage of total (%)	Cumulative percentage (%)		
1-4	321,044	49.59	49.59	742	2.3
5-9	166,814	25.77	75.36	1,104	6.6
10-19	100,517	15.53	90.89	1,336	13.3
20-29	29,092	4.49	95.38	688	23.6
30-49	18,163	2.81	98.19	676	37.2
50-99	8,524	1.32	99.51	566	66.4
100-199	2,375	0.37	99.87	315	132.6
200-299	425	0.07	99.94	102	240.0
300and over	402	0.06	100	247	614.4
Total	647,356	100	-	5,774	8.9

Source: Statistics Bureau/Statistical Research and Training Institute (2002).
[a]This is the number of construction establishments in Japan.

Table A4. Size Distribution of Construction Corporations by Registration Capital in Japan, 1997

Registration capital (thousand yen)	Contractors			Value of construction work		
	Number of firms	Percentage of total (%)	Cumulative percentage (%)	Value (million yen)	Percentage of total (%)	Cumulative percentage (%)
0-1,999	480	0.25	0.25	45,363	0.04	0.04
2,000-4,999	50,373	26.21	26.46	4,396,634	3.95	3.99
5,000-9,999	29,291	15.24	41.70	3,509,546	3.15	7.14
10,000-29,999	93,360	48.58	90.28	31,924,117	28.66	35.8
30,000-49,999	13,007	6.77	97.05	13,315,380	11.95	47.76
50,000-99,999	4,068	2.12	99.16	10,925,066	9.81	57.56
100,000-999,999	1,315	0.68	99.85	13,736,942	12.33	69.90
1,000,000-4,999,999	183	0.10	99.94	8,319,941	7.47	77.37
5,000,000and over	111	0.06	100	25,209,676	22.63	100
Total	192,188	100	-	111,382,665	100	-

Source: Statistics Bureau/Statistical Research and Training Institute (2002).

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Introducing Target Costing in Cost Planning and Control: a case study in a Brazilian Construction Firm

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Abstract
Target costing is a cost management technique that has been developed to be used mostly during early stages of product development, with the aim of reducing the final cost of the product, in order to obtain the expected profitability. In brief, it consists of a structured way of establishing the cost that must be achieved by the production of a product regarding its selling price and the expected profitability level. However, although these techniques have been widely used to support the product development process in the manufacturing industry, including organizations that claim to adopt a lean production approach, very little has been published of the use of target costing in the construction industry.
This paper present a case study carried out in a Brazilian construction firm that has been successfully using target costing to reduce the estimated cost of industrial and commercial projects. Results show the feasibility of target costing as a cost-planning tool during the early phases of construction projects.

Keywords
Cost management, cost information, production control, target costing, value analysis.

INTRODUCTION

According to Johnson and Kaplan (1987), traditional cost management systems fail to support decisions that affect the overall production result, because the available information from these systems is of little help to managers in their effort to improve production performance. Particularly in the construction industry, the gap between the information made available by traditional cost management systems and the goals set by the business is pointed as being one of the main problems that contribute for the poor performance of those systems (Barnes, 1977; Fine, 1982; Ostrenga *et al.*, 1992). According to Barnes (1977) and Fine (1982), the inadequacy of cost management accounting systems has resulted in the dissociation between cost management and production management. Traditionally, construction cost control consists basically of monitoring actual performance against cost estimates and identifying variances. As a result, traditional cost control systems have been much more useful to manage contracts than production (Howell and Ballard, 1996). Horngren *et al.* (1999) argue that cost management must not be isolated from other managerial functions, and should play a key role in the implementation of company strategies. Cost management systems should involve a set of processes required to ensure that a construction project is completed within the approved budget, including cost estimating, cost control and cost projection (Kim, 2002).

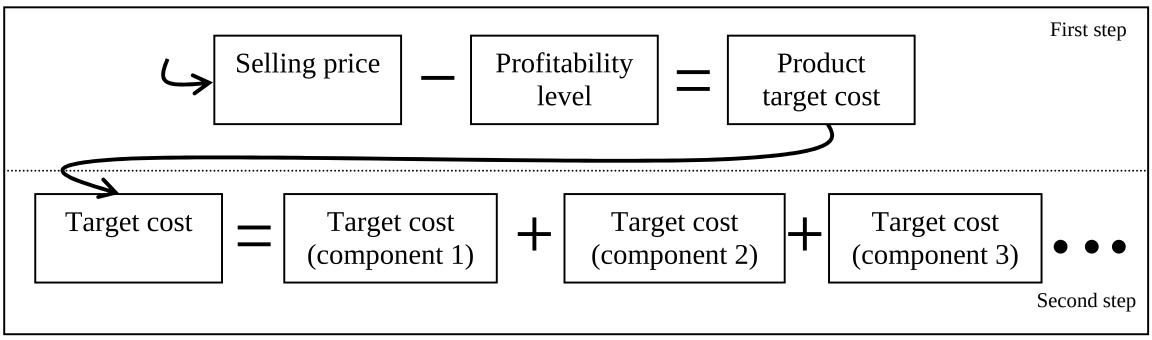
Uncertainty, variability, interdependence and complexity play a key role in the construction environment, and a major challenge for production management systems is to eliminate or to reduce the impact of those characteristics (Koskela, 2000). Moreover, the uncertainty related to the financial environment must also be considered, regarding the significant amount of capital required by construction projects (Barbosa and Pimentel, 2001). Cost management systems in construction must be dynamic, proactive and able to support different decision-making processes, in order to protect the business from the harmful effects of uncertainty, with the main objective of generating information to support decision-making, mainly concerned with cost reduction, value improvement and financial management. Therefore, an adequate cost management system is an essential step for any company to be competitive (Granja, Picchi and Robert, 2005).

This paper discusses the practice of target costing in the construction industry and presents the results of a case study carried out in a Brazilian construction firm that has been successfully using target costing to reduce costs and improve value in industrial and commercial building projects.

TARGET COSTING

Target costing has been widely used by some leading industrial companies with the main objective of reducing the final cost of the product in order to obtain the expected profitability while ensuring satisfactory quality levels (Maskell and Baggaley, 2003). It can be described as a systematic and structured way of establishing the cost and quality that must be achieved in the development of a product in order to reach the desired profitability (Cooper, 1995; Cooper and Slagmulder, 1997). Basically, it requires two main steps that are illustrated in Figure 1.

Figure 1: Target costing main implementation steps (based on Cooper, 1995)



As illustrated in Figure 1, the first step to implement target costing consists of establishing the target cost by subtracting the product's desired profit margin from its expected selling price. Secondly, the target cost of the product is distributed to its components, materials or systems, depending on the segmentation criteria adopted.

From this perspective, cost is seen as an input and not as an outcome of the design process. According to Cooper and Slagmulder, 1997, the target cost becomes the focus of all designers and main suppliers, due to the fact that it establishes quantitative objectives. As a result, it creates a clear and powerful pressure for cost reduction in the company, involving the development of products that satisfy customers and are able to be manufactured under the established cost. Granja, Picchi and Robert (2005) state that the target selling price establishes an acceptable and reasonable price for the client, while the target profit defines the company needs. Besides that, target costing has also been pointed out as a powerful mechanism for interacting with key suppliers (Granja, Picchi and Robert, 2005).

According to an exploratory study undertaken by Dekker and Smidt (2003), several manufacturing companies around the world make widely use of costing techniques that are similar to target costing. Such techniques are known by a diversity of names, being adopted especially in assembling firms, under circumstances of intense competition and high environmental uncertainty. However, Maskell & Baggaley (2003) argue that most existing cost reduction systems do not provide consistent mechanisms that enable them to understand and reduce costs. This is due to either the lack of tangible definition of the sum that must be reduced, or the lack of analysis of the requirements that add value to the customers.

Target costing in the construction industry

Based on Ballard and Reiser (2004), target costing has been used to some extent in the construction industry, although details of that practice have not been well documented. The same authors suggest that there is an opportunity to expand and improve the use of this practice in construction by increasing the understanding of this technique in the industry.

Ballard and Reiser (2004) pointed out that the relationship between the manufacturer and its main suppliers is a major difference between construction and other industries, in terms of using target costing. According to the same authors, long-term relationships with even first tier supplier are rare in the construction environment. The influence of the first tier specialty contractors with their own suppliers tends to be greater with service providers than with product suppliers, who are often much larger than the specialty contractors, and is usually larger than the general contractor themselves (Ballard and Reiser, 2004). However, one of the most significant paradigm shifts of modern business management is that individual business no longer competes as solely autonomous entities, but rather as supply chain (Lambert and Cooper, 2000). For instance, Toyota has long-term relationship with its suppliers, including fist, second and even third tier (Ballard and Reiser, 2004).

From a transaction-cost-economics perspective of the construction supply chain, Vrijhoef, Koskela, and Voordjik (2003) argue that there are three basic characteristics that must be regarded: asset specificity, uncertainty and frequency. According to them, during the pre-contract phase of construction projects, the asset specificity is low. However, it is high during the post-contract negotiations over variations and claims. As a consequence, during the pre-contract phase there is a narrow opportunistic behavior because the client can choose from many suppliers, contractors and architects. Therefore, as contracts are signed with a small number of parties, and due to the one-off nature of the work, these parties do not have to worry over their reputation. According to Granja, Picchi and Robert (2005), the rule of surviving in the rather competitive situation is that clients on one hand and main contract on the other, try to maximize their own benefits what?? resulting in a speculative culture in the construction sector.

Contracting uncertainty is related to the cost uncertainty, as well as the relatively high share of a project in the total turnover of the company (Vrijhoef, Koskela, and Voordjik, 2003). This may include projects conditions changes that cause cost flutuations (low productivity, design changes, etc) (Granja, Picchi and robert, 2005). Finaly, due to ever-changing project coalitions and the use of market-based bidding procedures, the frequency of transactions between parties in the construction industry can be regarded as low. Thus, an opportunistic behavior, in order to obtain as much benefit as possible before the end of project can be stimulated by the temporary character of relations.

Besides the difficult relationship within the supply chain, Ballard and Reiser (2004) also point out challenges related to the use target costing in the design process. First, they question how the relevant specialists can be involved in the design process, in order to carry out an effective collaborative process. Secondly, they argue that making trade-off decisions between project characteristics is a difficult task. Thirdly, it is wondered how design decisions must be driven to achieve the target.

CASE STUDY

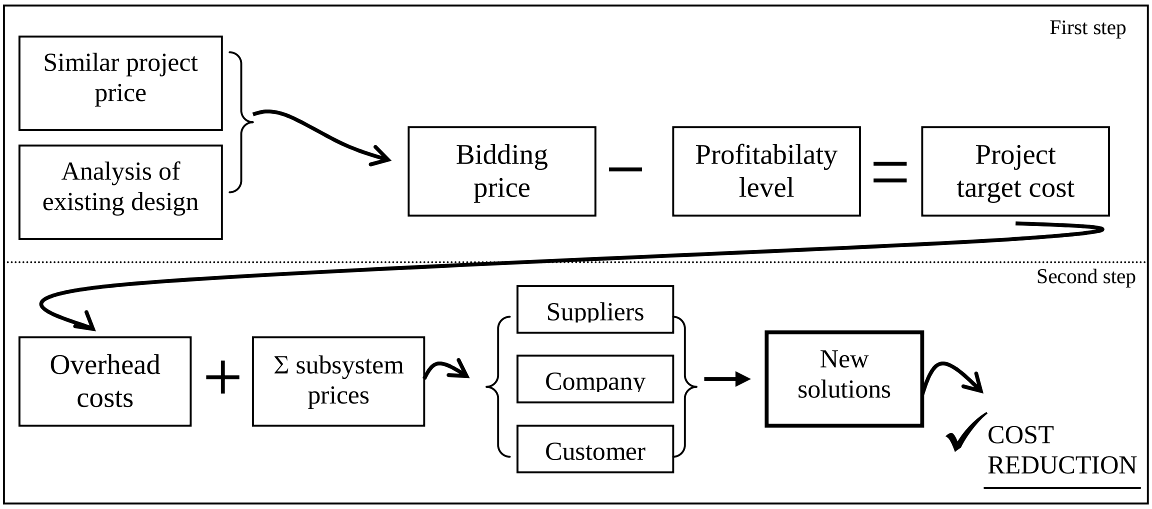
This case study was part of a research project that had as one of its main objectives the improvement of cost management systems in construction, resulting in a model for cost planning and control for construction projects. (Kern and Formoso, 2004; Kern, 2005). This case study consisted of the implementation of target costing as a cost planning tool for complex and dynamic construction projects during the design phase, in order to reduce the total cost and be able to produce competitive proposals for different industrial and commercial building clients.

The construction building company involved in this study has as its main market the construction and refurbishment of industrial buildings and hospitals. It is a firm that is strongly commited to the development and implementation of lean production principles and practices. In this context, it has successfully developed a production and safety planning and control systems, as well as has introduced some important innovations in the product development process. Since 2002, the company has been seeking to improve its cost management system because the directors had realized that some projects had not been successful due to inappropriated bidding prices. The cost estimating proccess used to be strongly based on traditional bills of quantities, produced by the cost estimating department with insufficient participation of production and contract managers.
The case study was carried out during the development of the design for an industrial building refurbishment project carried out for a steel mill company. The complexity of this project was much related to the fact that this building was part of an industrial site that remained in full operation. Moreover, the project duration, including design development and building, was relatively short (six months). The client commissioned the architectural and structural designs, which were developed to the sketch design level. The building consisted basically of a reinforced concrete structure, roof steel structure and tiles, and brick walls.

The Construction Company took part in a competitive bidding, in which several other construction firms had participated. The construction firm decided to use target costing since the bidding stage. Figure 2 presents schematically the steps that have been adopted by the company to introduce target costing.

The target cost was initially based on a previous similar project and also on the available design. Based on this information the final price of the project was established, and the target cost resulted from the subtraction of the profit margin expected by the firm directors. After establishing the project target cost, directors and the contract manager (who had experience in similar projects) established the target-costs for the main subsystems involved and estimated the overhead costs with the support from the cost-estimating department.

Figure 2. The use of target-costing by the construction company



For the negotiation with subsystem suppliers, costs was estimated adopting unit prices, initially established for each of them, based in past information, e.g. foundation (m^3), reinforced concrete pre-cast structure (m^3), steel roof structure (m^2).

Once the project started and the main suppliers were contracted, the Construction Company started to make collaborative meetings in order to develop detailed design, involving both the client and suppliers. Those meetings were conducted once a week, during the first two months, managed by the constructor contract manager. They jointly develop design solutions and production methods, aiming to meet requirements from both the client and the production system.

RESULTS

The most important changes introduced in the project consisted of a new conception of the foundations, reinforced concrete structure and roof steel structure, resulting in a reduction of 9,85% of the total estimated costs, as shown in Table 1. The cost figures have been changed due to the confidentiality of this information, although the proportions between cost items have been kept.

The new conception of the roof structure resulted in a reduction of 37% of the steel weight: in the first design provided by the client, 160,00T of steel were needed, while in the new design this amount was reduced to 100,00T. The subsystem supplier, who was hired by the construction firm, played a key role in developing this new solution.

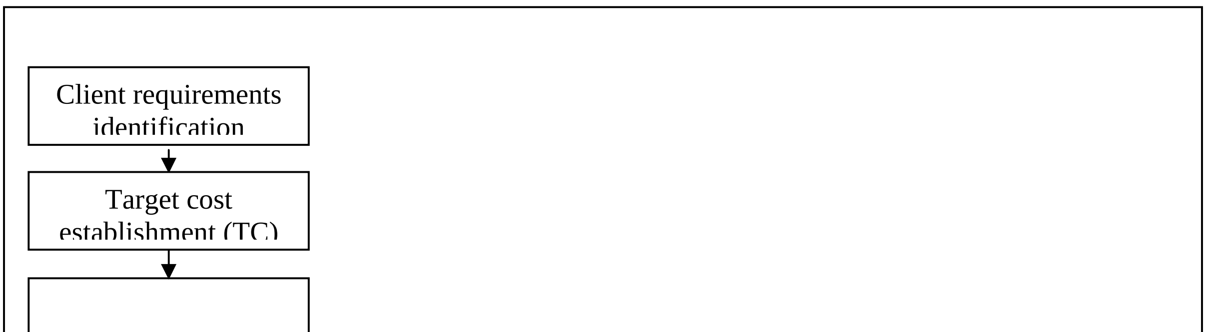
Also, some major changes were made in the concrete structure. The pre-cast concrete supplier proposed a different column modularization, increasing the beam span from 5 to 10 meters. This was possible because the total load was relieved by replacing external walls for structural tiles and using gypsum plasterboard for the internal walls, instead of ceramic bricks. Moreover, due to those changes, the foundation structure was also reduced.

Table 1. Total cost reduction from new engineering solution

Description	Client design	New design	Cost reduction	Solution
Overhead costs	$ 61,11			
Preliminary services	$ 53,54			
Foundation	$ 56,98	$ 48,00	18,71%	Beams elimination
Concrete structure	$ 205,96	$ 174,49	17,96%	New modularizations: pillars elimination
Walls	$ 87,74			
Concrete floor	$ 67,37			
Windows/doors	$ 58,42			
Roof	$ 475,32	$ 417,20	13,92%	New structure conception
Painting	$ 22,27			
Sanitary installation	$ 9,85			
Total	$ 1.098,47	$ 1.000,00	9,85%	

From this case study, the construction firm decided to implement and use target costing during the early planning phase (before tendering) of future projects in a structured way, following the flowchart presented in Figure 3, that also describes tasks and responsibles.

Figure 3. Target cost flowchart to be followed by the construction firm



Task	Responsible
Identify requirements of different clients, including everyone involved	Managing directors, commercial manager, cost estimating manager
Establish the project target cost	Managing directors, commercial manager, cost estimating manager
Identify the resources that are needed and estimate direct cost	Cost estimating sector with support form production managers
Analise the estimated cost comparing it with the established target cost	Managing directors, commercial manager, cost estimating manager
Estimate the overhead costs and produce a technical proposal	Production manager and managing directors
Define the suppliers and negotiate with them	Managing directors, commercial manager

According to the Figure 3, managing directors, commercial manager and cost estimating manager must identify different requirements from the perspective of the client, the firm and the subsystems suppliers. The second task consists of establishing the target cost of the project, involving the same people. Afterwards, the cost estimating sector has to identify all the resources (or subsystems) needed to estimate the direct cost of the project. This task must be carried with help of production managers in order to take into account the demands of the production system, such as construction methods, capacity, durations, etc.

Once the direct costs are estimated, managing directors, the commercial manager and the cost estimating manager assess the estimated cost in relation to the established target cost. Then the directors and production managers estimate the overhead costs and produce a technical proposal, and invite the main suppliers.
An executive committe (formed by directors, the contract manager and the production manager) start negotiating with the suppliers in order to produce the final bid.

CONCLUSION

Diferently from other target costing implementations presented by bibliography, both in in the construction industry and elsewhere, in this case study the introduction of this cost management technique started before the construction firm had chosen its main suppliers. In fact, the main suppliers were choosen after the contract was signed with the client. As a consequence, the first design analysis and the efforts to develop new solution were carried out by the firm solely. After the contracts were signed, the main suppliers and people from the construction firm worked together in order to improve the product development process, resulting in a total cost estimative reduction of 9,85%.

In this case, value analysis was not properly applied. The new solution developed were focused in cost reduction, not so much in value improvement. Those solutions were concerned with mostly changes in the oncrete strucuture and cladding. Further investigation on the joint implementation of target-costing and value analyses in construction projects is necessary.

According to the contract manager of the construction company, the main difficulties of using target costing and value analysis during the early stages are: (a) reliable cost estimates are hard to obtain due to the very short time available and the lack of historical data; (b) integrating some suppliers at the early stages of the project is hard; (c) there is not enough time to capture customer requirements during the cost estimating process. Also, he also pointed out the difficulty of keeping the target cost after the contract is established since the client tends to increase their demands in terms of requirements to be fulfilled but there is a limit budget.

Moreover, cost reduction efforts may also be undertaken after the design phase (Kern and Formoso, 2004; Granja, Picchi and Robert, 2005). In this context, the combined use of target and kaizen costing should be properly investigated through case studies, regarding cost management as a process that involve different phases of a construction project.

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Hotel Renovation Projects and LCC

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Abstract
LCC analysis entails the calculation of cost over useful or projected life of an asset. However, building components and/or finishing materials do not usually complete their projected life spans. Certain types of buildings undergo renovations many times before they are declared redundant and finally torn down; hotels are a point in case. During such renovations and refurbishment works most of the finishing material is replaced by newer and more fashionable one. This study was conducted to ascertain which materials are most likely to be replaced well before their useful life ends and which are used to their full potential; the intent was also to determine the reasons for such replacements and the frequency of renovation projects.

Data related to renovation projects of three five star hotels in Ankara was obtained and analysed. An insight was gained into the reasons for renovation works, and the types and amount of material replaced. A comparison was made between the actual useful lives of such materials with their projected life spans.

It was concluded that finishing material and components that are used in hotel construction need not have long life spans, since they are likely to be replaced even before they start to deteriorate, or they should be recyclable. Also, conventional techniques which are designed for permanence (such as cementing, gluing or welding), should not be used for incorporating such material.

Keywords
LCC; Renovation projects; finishing material; hotels; Turkey

INTRODUCTION

All buildings deteriorate with time but their life span can be extended with regular, periodic and systematic maintenance. Maintenance and refurbishment are an important aspect of operations in the hospitality sector. Five-star hotels have to be even more particular in this respect as they have to provide not only comfort and specialized services to their guests but also style. In order to remain popular they have to keep up with fashions and trends in the hotel industry; this means that even if the furnishings and fixtures are in mint condition there arises a need to completely refurbish them again in keeping with the current style. Since Life Cycle Costing (LCC) focuses on the dollar cost of building, operating, maintaining and refurbishing a structure throughout its life cycle, the costs for such refurbishment contribute significantly towards the high LCC of hotels.

The operational stage of a hotel life cycle is significant, both from an economic and environmental perspective. This phase, which includes running, maintaining and refurbishing, typically lasts from 25 to 50 years; on the other hand, with proper maintenance, regular refurbishment and renovation, the life span of a hotel building can be significantly extended. Some of the current operating hotels are located in buildings erected centuries ago [Bohdanowicz, 2003].

Stipanuk and Roffmann (1992) divide the life-cycle of a hotel in three phases. In the 1st phase it dominates the social and business scene because it is new, and investment in this phase is made to maintain its popularity. In the 2nd phase its popularity and occupancy rates diminish so it needs refurbishing to keep up with the competition. In the 3rd phase, changes in market demands result in either a change of management or a major overhaul. The authors further classify renovations of hotels into three categories: minor renovations that are undertaken every 6 years; major renovations that are done every 12 to 15 years, and restoration that needs to be done after 25 to 50 years.

SURVEY

The Turkish Ministry of Tourism specifies minimum standards for different types of accommodations for tourists. Depending on their category these standards outline the minimum requirements for guest rooms and other facilities to be provided in hotels. For example, in order to obtain a license for a five-star luxury hotel, the owners must provide such facilities as indoor swimming pools, saunas, convention centers for conferences, ballrooms to accommodate large social gatherings and congresses; meeting rooms with the latest technology, exhibition halls, movie theatres, shopping centers, restaurants, bars, and even discos. Similarly, the guest rooms can be equipped with specialized facilities to serve the diverse needs of the guests, such as non-smokers, left-handed or even disabled guests. There are around 220 five-star hotels in Turkey and nine of these are located in Ankara; data pertaining to three of them, which belong to reputable international chains of hotels, have been obtained. For the sake of anonymity, these hotels have been referred to as hotels A, B, and C.

Methodology

Data pertaining to refurbishment/renovation projects of the three abovementioned five star hotels in Ankara was gathered in January 2005. Two of these hotels belong to chains of international repute while one is a local hotel of historical importance which has recently been taken over by another international chain. Although, major renovations included such public areas as the lobby, conference- meeting rooms, ballroom, restaurants etc, only data for guestrooms has been analyzed in this paper, as the design decisions for one room is repeated hundreds of times over. The three hotels and the type of renovation works are described in more detail below. Table 1 lists the various types of accommodation available for guests in these hotels. In addition to those listed below, Hotel C has 2 Diplomatic suites and Hotel B has an entire floor converted into small apartments.

Table 1. Types of accommodation provided in five-star hotels of Ankara, Turkey.

	Presidential/ royal suite	standard rooms	standard suite	businessmen's / executive suite	Smart room/ club room	for non-smokers	for left-handed	for the disabled
Hotel A	1	110	26	23	14	0	0	2
Hotel B	1	323	26	51	0	0	0	0
Hotel C	1	250	32	2	23	24	5	3

Hotel A

Hotel A was the first five-star hotel to be built in Ankara, the capital of Turkey. This hotel was completed in 1966; and for the next 20 years it was the only five-star luxury hotel in the city. It consists of a built-up area of 22,920 m2 spread out on 22 floors (including 3 basements) of which 14 floors are devoted to standard guest rooms. The hotel has the usual facilities of restaurants, conference rooms, ballrooms swimming pool, etc.

This hotel has recently been completely refurbished by its new management and major changes have been incorporated. Although, the total number of guest rooms has been reduced from 193 to 176 the variety of accommodation being offered has increased and improved. For instance, the number of standard rooms has dropped from 178 to 110, while the number of suites has been increased from 14 to 26 and the number of executive suites from 1 to 23. Moreover, 14 rooms have been converted into club-rooms and 2 into special rooms for handicaps. To answer current needs, seven meeting rooms have also been added while the number of ballrooms has been reduced from two to one. Apart from improved accommodation, several theme restaurants and bars have also been built.

Hotel B

Inaugurated in 1986 this hotel has 16 floors reserved for guests, with 22 rooms on each floor. Moreover, a complete floor has been converted into extended-stay apartments. The 55m2 apartments include a bedroom, a living room, a kitchenette and a 50 m2 private terrace. These apartments are equipped with state-of-the-art facilities. In addition to standard guest-rooms and apartments, 51 executive rooms have been provided on the top three floors. The hotel offers an indoor swimming pool, fitness centre, sauna, a Turkish bath, two fully equipped meeting rooms and a ballroom that can accommodate up to 1,100 guests.

According to an earlier study on Hotel B, finishing material in guest rooms has been listed as follows: Ash veneered chip-board panels for suspended ceilings, vinyl wall-paper with timber beading for trimming, wood for pelmets and skirting and gypsum plaster and paint for exposed ceilings [Ozgurel, 2001]. However, all of these materials have been replaced recently without regard for durability. For example, robust wooden trimmings and ceilings have been discarded to install flimsy gypsum trims and tiles, for the sake of harmony with the new color scheme and style. All the guest rooms have been completely re-decorated in light colors with added features, such as a specially designed working desk equipped with high-speed internet connection and data-port, to facilitate a comfortable working environment.

Hotel C

A major renovation project was recently undertaken in Hotel C, where all the rooms, as well as the club lounge were completely refurbished in 2001-02. The renovations also provided an opportunity to incorporate the latest technology in the guest rooms and create an appropriate environment for both business and leisure guests. All guest-rooms have safes, modem connection, fast internet access, plus plugs suitable for both 110 & 220 V and energy saver.

Five rooms have been prepared for left-handed guests by incorporating special features, such as the opening direction of the doors and windows i.e. main entrance, mini-bar, in-room safe, placement of the electrical outlets, make up mirror and hairdryer. Also, specially designed left-handed amenities have been provided such as: ruler, cork screw/bottle opener, wall clock and even a reversed logo on guest pens. Additionally, three rooms and attached bathrooms have been specially designed to provide ease, safety and comfort to the disabled guests.

In 2003, construction on a new hotel wing comprising of a congress and cultural center was started and part of the existing ballroom area was demolished to be utilized as a foyer that is also the integration point for the Convention Center. This major renovation was undertaken to modernize the lobby as well as the theme-restaurants and bars.

RESULTS AND DISCUSSION

Data and information pertaining to the three hotel renovation projects was analyzed from the point of view of the reasons for and frequency of refurbishments, and the type and amount of material replaced. As mentioned earlier, since the volume and type of work may vary greatly in public spaces and since they are unique designs only guestroom refurbishments, which are repeated hundreds of times over, have been studied within the scope of this paper. Table 2 presents the volume of renovation work done on the guest-room floors of the three hotels; only those work items have been included that were common to all three hotels.

Table 2. Volume of renovation works in the three five-star hotels in Ankara, Turkey.

	DESCRIPTION OF RENOVATION WORKS		**Hotel A**	**Hotel B**	**Hotel C**
	CIVIL WORKS	**UNIT**	**QTY**	**QTY**	**QTY**
FLOORING	HEAVY DUTY BOARD ROOM TYPE FIRE PROOF CARPET (80 wool/20 nylon) WITH FELT UNDERLAYER FOR SOUND INSULATION	M2	7656	7272	7560
SKIRTING	HARDWOOD SKIRTING (VARNİSHED)	MT	970	8092	3296
FALSE CEILING	GYPSUM BOARD(FIRE RESISTANT) SUSPENDED CEILING	M2	6050	4413	4563
CEILING	SATIN FINISH ACRYLIC PAINT (3 LAYERS)	M2	8596	11921	4924
WALL COVERINGS &FINISHES	TEXTILE BACKED VINLY WALL PAPER	M2	15000	20041	12454
DOORS	WALNUT VENEERED SOLID WOOD FIRE RESISTANT DOORS WITH FRAMES AND FITTINGS	EA	370	720	387
FURNITURE/ FIXTURES	GUESTROOM FURNITURE UNITS INCLUDING ALL ACCESSORIES	SETS	177	352	180
FIXTURES	BATHROOMS	SETS	177	360	186

From the table above, it can be seen that the guest rooms underwent major overhauls. The walls were stripped and re-papered or painted; the flooring was replaced with new carpeting; the ceilings were re-painted or false ones replaced; new door-frames, -sashes and hardware were installed; all bathrooms were refitted and all furniture and furnishings were changed. In short, the structure is stripped down to its core and fitted anew. The following three sections present some answers to the questions posed at the beginning of this research, as to the reasons for, frequency of and volume of refurbishment works.

Reasons for refurbishments

Renovation works in hotels are undertaken mostly from the point of view of customer satisfaction. In Hotel B the guests are asked to fill up a questionnaire to assess their satisfaction. Some of the questions are posed to determine those aspects which impressed the guests most. The aim is also to find out whether the guests were bored with the decor or not. Unless there is a sudden change in fashion trends refurbishment is planned and scheduled in view of this information.

Renovation of guest rooms, bathrooms and common/entertainment areas is mostly done to keep up with new fashion dictates on style and color schemes. Meanwhile, major renovation of rooms takes place also because there is a need to provide extra and different facilities to the guests. For example, to keep up with new technologies, the electrical wiring system had to be replaced in order to provide high-speed internet connection, data-port, satellite TV, DVD, fax machine, conference call availability photocopy/printer machines, as well as plugs suitable for both 110 & 220 V. Rooms for left-handed guests required replacement of all fixtures; whereas, rooms for the disabled had to be equipped with special safety features.

In view of the market demand some rooms were combined to make extra suites and some were converted into special guest rooms for non-smokers, disabled or left-handed guests, while some were knocked down and the space was used to build self-contained apartments for extended stay. Apart from guest rooms, major renovation works included the creation of theme restaurants and bars, hi-tech conference and meeting rooms.

Frequency of refurbishment

Hilton International Engineering manual gives the useful life of carpets in guestrooms as 6 years, drapes and spreads is 5 years, beds 15 years, mattresses 12 years, Venetian blinds 8 and furniture 10 to 12 years [Ozgurel, 2001]. However, the expected life or the predicted life of these materials is much longer in reality. Material such as ceramic floor tiles can last for more than 50 years and yet in Hotels B and C they were replaced after only 10 years. Marble flooring lasts for hundreds of years and yet it was replaced in Hotel B in order to keep up with the current fashions.

Hotel A is undergoing a major overhaul almost 50 years after it was first opened. Since the management has changed it was not possible to obtain information with regard to the frequency of refurbishment in this hotel. However, the bill of quantities for the renovation works stipulates a certain amount of material to be kept in store for contingencies in the next ten year period; hence we can assume the proposed renovation frequency is every ten years. On the other hand, Hotel B has regular renovation cycles in keeping with the recommendations of its management; minor renovations are done every 5 to 6 years, while major ones are done every 10 to 12 years.

In Hotel C the first renovations were undertaken after 9-10 years in the years 2001-2002, in the guest rooms only. The reason for refurbishing then was to replace the out-dated furniture with more fashionable one and not because the upholstery was worn out. In fact, the old furniture and furnishings were in such good condition that the hotel staff was given the option to buy them at nominal prices. What could not be sold was sent to furbish the hotel's branch in Kusadasi, Turkey. This year the bathrooms, Lobby and restaurants are being renovated in this hotel. Since the color scheme in the bathrooms was very light and current fashion dictates darker shades, all the marble surfaces have been ripped out and replaced. On the other hand the lobby and restaurant floors were renovated to blend in with the style of the new annex building and even the façade was changed to create harmony and unity.

Type and amount of material replaced

The grouped data for the renovation of guest room floors in the three hotels was gathered from the Bill of Quantities (BOQ) of Hotels A, B and C. As mentioned earlier, data for only the guest rooms and corridors on the guest room floors has been analyzed. The BOQ is given as an appendix to this paper. It should be noted that since Hotel A was undergoing a major overhaul which involved conversion of rooms into suites, the amount of work is significantly more than that done in the other two hotels. Consequently, more variety and amount of material was used in Hotel A.

Most significant are the materials used for finishing the surfaces, such as vinyl wall coverings, carpets and suspended ceilings. Additionally bathroom fittings and fixtures as well as doors (with frames) have been replaced in all the hotels. For example, a total of 22,500 square meters of carpeting and 5,500 square meters of floor tiles were replaced. 7,500 square meters of the old suspended ceiling was replaced with 6,050 square meters of new one in Hotel A, while hotels B and C each had approximately 4500 square meters of suspended ceiling replaced. The walls were covered with embossed vinyl wall-paper, which was replaced with new wall paper to the tune of 15,000 square meters in Hotel A, 20,000 square meters in Hotel B and 12,500 square meters in Hotel C; most of this washable wall-paper is imported. The number of doors replaced with new ones is also significant; the number of new doors in Hotels A, B, and C were 370, 720 and 387 respectively.

CONCLUSIONS

Billions of dollars are spent on hotel refurbishment projects around the world. For instance, Hotel B belongs to an international chain which operates 2,700 hotels in 70 countries. This chain of hotels has spent more than a billion US dollars on renovating 'flagship' properties and its management states that renovations are on-going in the system in order to maintain excellence in appearance and accommodation. On the other hand, Hotel A has recently been taken over and renovated by another international chain of hotels which owns 91 hotels in 15 countries. Finally, Hotel C is one of the 730 hotels operated by its chain in 80 countries.

It therefore follows that, the BOQ presented in this paper is representative of the volume of refurbishment works in guest-rooms of 4,319 hotels, belonging to three international chains of hotels. This translates into more than 13,000 guest rooms. The total number of hotels all over the world are not accounted for, however just three chains are enough to demonstrate the enormity of the amount of hotel refurbishment works going on. The BOQ for renovation works given as appendix to this paper reflects the variety and volume of civil works that need to be carried out during guest-room refurbishment projects.

For a hotel to become a viable investment it has to be located in areas where there is a demand for temporary accommodations. These locations are either central business districts in large cities or near tourist attractions. Such locations are usually hard to come by, therefore, investors prefer to buy and renovate an older property. Refurbishments and renovations not only mean an enormous amount of investment every 10 to 12 years but also generate huge amounts of waste. Hence, any material that has been dumped as waste even before it has started to deteriorate due to wear and tear, let alone before the end of its expected lifetime, adds considerably to the LCC of the hotel.

RECOMMENDATIONS

As mentioned earlier, Hotel B had 4500 square meters of wooden suspended ceiling replaced by gypsum board false ceilings, which are not as durable as wood. Even the wooden pelmets were replaced with gypsum ones. From these examples it can be seen that sometimes good quality and durable materials are replaced with those of poorer quality and strength. Additionally, these materials and components, which are replaced in bulk just after a few years, are incorporated into the structure with permanent joints, anchors and glues. Since the hotel maintenance and renovation guideline dictate a shorter useful life than their expected life, it would be prudent to use replaceable material and components with de-mountable joints.

Since Furniture is changed after every 8 to 10 years it is advisable not to use fixed furniture or parts thereof, such as wall mounted headboards or night stands. It would also be more economical and healthy if floors were covered with wooden parquet or marble tiles depending on the climatic region, and rugs were used instead of wall to wall carpeting, which attracts dust and stains easily. These rugs can be washed or replaced at considerably lesser costs.

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APPENDIX

Table A1. Bill of quantities for renovation works in the three five-star hotels in Ankara, Turkey.

	DESCRIPTION OF RENOVATION WORKS		Hotel A	Hotel B	Hotel C
1	**CIVIL WORKS**	**UNIT**	**QTY**	**QTY**	**QTY**
A	**DEMOLITION WORKS**				
1A1	DEMOLITION OF BRICK WALL	M3	1250	148	
1A2	DEMOLITION OF R/C	M3	35		
1A3	REMOVAL OF SUSPENDED CEILINGS	M2	7100	105	
1A4	SCRAPING OF EXISTING WALL PLASTER AND CERAMICS	M2	2680	20119	
1A5	DEMOLITION OF EXISTING FLOORING AND REMOVAL	M2	8900	10054	
1A7	DEMOLITION OF PIPING AND MECHANICAL DUCTS	TON	350		

1A8	DISMANTLING ALL ELECTRICAL SYSTEMS	MT	15000		
	REMOVAL OF DOORS WITH FRAMES	SET		480	
	REMOVAL OF BATHROOM FITTINGS AND FIXTURES	SET		360	186
E	**FLOORING**				
1E1	LEVELLING CONCRETE	M2	1586		
1E2	SELF LEVELLING SCREED	M2	9500	9615	
1E4	CERAMIC FLOORING	M2	2805	2784	
1E7	HEAVY DUTY BOARD ROOM TYPE FIRE PROOF CARPET (80 wool/20 nylon) WITH FELT UNDERLAYER FOR SOUND INSULATION	M2	7656	7272	7560
1E8	1st QUALITY WALNUT FINISHED PARQUET FLOOR WITH VARNISH w	M2	1100		
1E9	MECHANICAL POLISHING OF EXISTING MARBLE FLOORS	M2	800		
1E10	BATHROOM DOOR THRESHOLD	MT	150		
1E11	SOLID WALNUT GUESTROOM ENTRANCE DOOR TRESHOLD	MT	150		
F	**SKIRTING**				
1F1	HARDWOOD(WALNUT) VENEERED OVER MDF VARNISHED SKIRTING	MT	5400		
1F2	HARDWOOD SKIRTING (VARNİSHED)	MT	970	8092	3296
1F3	CERAMIC SKIRTING	MT	2100		
1F4	SOFTWOOD SKIRTING (VARNISHED)	MT	450		
G	**CEILING**				
1G1	CEILING PLASTERING	M2	1670	11665	
1G2	GYPSIUM SPACKLING	M2	11170	7846	
1G3	GYPSIUM BOARD(FIRE RESISTANT) SUSPENDED CEILING	M2	6050	4413	4563
1G6	SATIN FINISH ACRYLIC PAINT (3 LAYERS)	M2	8596	11921	4924
K	**PARTITION WALLS**				
1K1	HOLLOW BLOCK BRICK WALL(20 CM)	M3	100	217.6	
1K2	GYPSIUM BOARD WALL (DOUBLE SIDED WATER &-FIRE PROOF)	M2	4150		
1K3	SINGLE SIDED GYPSIUM BOARD WALL	M2	1500		
1K4	GYPSIUM BOARD PARTITION WALL (DOUBLE PANEL)	M2	500		
1K5	HOLLOW BLOCK BIMSCONCRETE WALL (10*39*19)	M2	500		
L	**WALL COVERINGS&FINISHES**				
1L1	INTERIOR WALL PLASTERING	M2	12839	25497	
1L2	GYPSIUM SPACKLING	M2	12839		
1L3	SATIN FINISH ACRYLIC PAINT (3 LAYERS)	M2	12839	2662	
1L4	OIL PAINT(3 LAYERS)	M2	500		
1L5	CERAMIC WALL TILES	M2	3250		
1L6	WALNUT FINISH WALL PANELS (VARNISHED)	M2	240		
1L7	MARBLE WALL COVERING(TEXTURED FINISH)	M2	320		
1L8	COLOURED BACK GLASS WALL TILES	M2	200		
1L9	TEXTILE BACKED VINLY WALL PAPER	M2	15000	20041	12454
1L10	MIDRAIL ON CORRIDOR WALLS OF GUESTROOM FLOORS (150 MM) WALNUT VENEER OVER MDF+VARNISHED	MT	700		
M	**DOORS & WINDOWS**				
1M1	WALNUT VENEERED SOLID WOOD FIRE RESISTANT DOORS WITH FRAMES AND FITTINGS	EA	250	720	387
1M2	TOUGNENED GLASS SHOWER DOOR	EA	178		

1M6	EXECUTIVE SUITS FIRE RESISTANT WALNUT DOORS INCLUDING FRAME AND FITTINGS	M2	100		
1M7	SOLID CORE LAMINANT FACING WOODEN DOORS WITH FRAME	M2	120		
1M8	SOLID CORE SOUND PROOF WOODEN DOORS WITH FRAME AND FITTING	M2	20		
1M9	ALUMINIUM WINDOW FRAME REPLACEMENT WITH (4+4 DOUBLE GLAZING GLASS) 1/4 OF GUEST ROOMS	M2	710		
N	**FURNITURE/ FIXTURES**				
1N1	GUESTROOM FURNITURE UNITS INCLUDING ALL ACCESSORIES	SETS	177	352	180
1N2	UPHOLSTERIES & LINENS & DRAPERY & CUSHIONS	SETS	354		
1N6	SHELVING UNITS	EA	187		
1N7	ALL MIRRORS	EA	200	352	
	BATHROOMS	SETS	177	360	186

Tenure choice, housing demand and credit constraints in Chile

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Abstract
According to the socioeconomic survey CASEN 2003, 70% of Chileans own their dwellings, though this number reduces somewhere around 50%, when considering only Santiago. Even though applied literature on the topic is not scarce, there have been no previous efforts towards understanding the determinants of such an important decision in the case of Chile. Theoretical work, -notably that of Henderson and Ioannides (1983) - establishes that the discrete choice between buying and renting a house should not be dealt with separately from the continuous flow of expenditure in housing services. The probability of owning a house is the result of combining the probability of wanting to own (pure tenure choice) and that of being able to do so (no credit constraint). In this paper using CASEN 2003 and maximum likelihood techniques not only do we quantify parameters of housing demand but also identify the variables determining tenure choice and credit constraints. As the estimated model resembles that of Henderson and Ioannides (1986) it also allows for international comparisons.

Keywords
Tenure choice, credit constraints, housing demand, maximum likelihood estimation

INTRODUCTION

Approximately 70% of Chilean households own their dwellings. However this figure has the influence of public housing policies, which have traditionally favored owning. As a matter of fact, when public houses are not included in the analysis owners amount only to 30%.

The main goal of this paper is not to provide financial market conditions favoring owning or renting, but to understand and quantify (at least partially) the most important determinants of housing demand, taking special consideration to the housing tenure choice decision.

Such an issue turns out to be important not only as an academic concern, but also for constructors and public authorities. The formers may be interested in gaining a deeper knowledge into the characteristics of their clients. Specifically in what regards their difficulties to reaching the credit market, and their response after changes in prices and in incomes. The latter are generally a very important participant in housing market (specially in developing countries), by means of public policies. Getting a better knowledge of involved parameters may be of aid when designing new public programs.

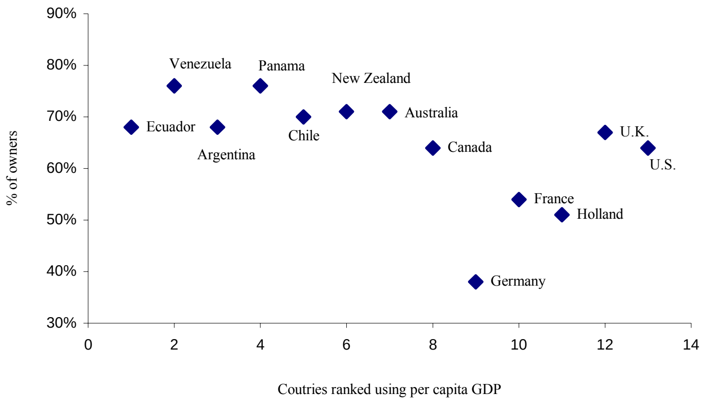
The paper is organized as follows. Next section identifies some stylized facts which will be important later on, while theoretical and empirical issues are taken care of in the third section. Specifically a micro founded model of housing tenure choice is presented and at the same time its econometric counterpart will be derived. Before estimating, the forth section gives a synthesized recollection of data sources and eventually provides the most important results. Finally there is a sum up of the most relevant conclusions.

SOME STYLIZED FACTS

Social and Economical Characterization Survey (CASEN) shows that more than 70% of Chileans own their own home in 2003. As it will be reflected in the results later, such a behavior has been influenced by social housing policy that has been pro owning. As a matter of fact, when public aid beneficiaries are excluded from sample, owners step down to 30% in average. Notice, though, that the survey asks families whether they own or not, but since some households that wish to own may be credit constrained, such a question includes not only pure choices but also those affected by other constrains. The distinction between the desire and the capability aspects when deciding to buy a house is one of the most important issues in tenure choice literature.

Different countries face alternative conditions in the housing market, which in turn affect the percentage of owners. For instance, public housing renting is usual in Germany, resulting in a higher proportion of renters than that observed in the U.S., a country with a strong pro owning income tax. Figure 1 displays per capita GDP ordered countries and the percentage of owners observed in each case.

Figure 1. Housing ownership in different Countries



Source: BID, CEPAL and own making.

As can be seen in the previous figure, Chile does not qualify as an outlayer, but it is important to enquire if such a percentage of owners remain constant across different society clusters. Firstly, it is interesting to classify owners and renters according to their income. Only 15% rent in the first quintile, while this figure steadily increases to more than 35% in the richest 20% of the population. Housing policy in Chile has been favorable to owning, given it directly transfer the possession to the poorer and it strongly subsidizes for slightly higher income groups. Thus, once publicly assigned houses are dropped out of the sample owning percentages change dramatically: renters sum up to 60% in the first quintile and reduces to 20% in the last one. As a whole this highlights a very important fact: low income may condition owning only if public housing policy does not operate. That is, for low income families, public housing policies act as an income supplement.

Other statistics show that households renting tend to be younger, thus there may be life cycle issues involved and it may be the case that younger families face higher credit constraints.

TENURE CHOICE THEORY AND ESTIMATION ISSUES

A house can be thought of as a stock able to produce housing services, which can either be enjoyed directly by the owner (in which case she would be considered an owner-occupier) or be rented to another party. The amount of services produced by a unit of housing stock depends on its rate of utilization, which is considered to be the choice of the occupier. Equilibrium in asset portfolio implies that owning a house does not differ from any other possible holdings, unless uncertainty issues are introduced. With perfect certainty tenure choice depends on a key externality as identified by Henderson and Iaonnides (1983). Since the rate of utilization of the housing stock is a control variable for the occupier, when she is not also the owner, only part of depreciation is reimbursed. In such case, it becomes optimal for the occupier to choose a utilization rate higher than that desired by the owner. Thus, the existence of this externality in addition to full certainty imply that owning dominates renting, that is, in such a framework there is no room for renters.

Investing in housing for rental becomes attractive if, for instance, housing investment involves no risk considerations, whereas there exists a second asset which is not risk free. Then, in order to consider owning, the advantage of avoiding the externality must be weighted against risk preferences. Henderson and Iaonnides (1983) have proven that under those circumstances individuals with lower wealth levels would become owners, and richer agents would rent. However, this trend can be distorted if a progressive tax structure, which favors owning, is imposed.

It is as well possible to suggest that poorer households, in developing countries especially, would choose to own given that they have restricted access to the capital market (due to informational issues, for instance) and normally bear the risk of losing capital to high inflation rates. In such a framework a house outstands as a very trustworthy means to securing one's wealth.

Theoretical analysis of housing tenure choice shed light over two key aspects. On one side it emphasizes the distinction between i) owning or renting and ii) housing expenditure associated to one or the other. Notice that, given the externality, they may differ: the same person may choose a higher expenditure path if he owns. On the other even though both former choices are conceptually different, they are decided simultaneously and thus it is not proper to estimate them separately. Consequently, the first decision will be regarded as "discrete choice", since it implies a binary election: buy or rent, while by "continuous choice" the second portion of the decision will be identified, precisely because expenditure is a continuous variable.

The "discrete choice" is the result of two events, given credit constraints. That is, the probability of owning requires that the individual wants and is able to own. Indeed, credit constraint issues affect the capability of owning. A person will want to own if the benefit accrued by such a choice is higher than that of renting **the same unit**. Since such a choice involves pure desire only it is known as 'pure tenure choice'. To deal with the capability constraint the econometric model poses a credit constraint function that allows to identify if families have constraints even though they do not declare it openly. In simple words it proceeds in the following steps: 1) defining a set of family characteristics for those who buy; 2) wondering whether other families that have the same characteristics do not buy; and 3) determining if those families have any systematic pattern that differs them with those who buy. For instance take two families that face the same capital and rental prices for a housing unit and are alike in every aspect but the work status of the husband: the first one has a labor contract and the second one does not. If in average families like the first end up owning and those in the second group rent, then it will be claimed that not having a labor contract restricts credit access.

Following Henderson and Ioannides (1986) should the i-th family choose to own, it will enjoy an utility level given by:

$$V_{Oi} = V(P_{Oi}, P_x, Y_i) + e_{Oi} \qquad (1)$$

where V stands for the indirect utility function; P_{Oi} is the net price of owning one unit of housing (considered as one square meter); P_x represents the price of other goods; Y_i is real permanent income and e_{Oi} is the expression for the random error component. Contrarily if the family's choice is to rent, its utility is given by:

$$V_{Ri} = V(P_R, P_x, Y_i) + e_{Ri} \qquad (2)$$

P_R is the renting price of one unit of housing, which varies according to the zone where the family wants lo live and y e_{Ri} stands for the stochastic error. It will be assumed that both e_{Ri} and e_{Oi} follow normal independent distributions with zero mean and variance given by σ^2_e. A family will want to own if:

$$V_{oi} - V_{Ri} > 0$$

The probability of such an outcome is given by: $p_i = \Pr(V_{Oi} - V_{Ri} > 0)$. Using (1) and (2):

$$p_i = \Pr\left(V(P_{Oi}, P_X, Y_i) - V_{Ri}(P_R, P_X, Y_i) > e_{Ri} - e_{Oi}\right) \qquad (3)$$

Noticing that e_{Ri} and e_{Oi} follow a normal distribution and using Φ to denote the standard accumulated function (3) can be expressed as:

$$p_i = \Phi\left(\frac{V(P_{Oi}, P_X, Y_i) - V(P_R, P_X, Y_i)}{2\sigma_e^2}\right) \qquad (4)$$

Since the former probability involves no constraints it is the mathematical expression for the 'pure tenure choice' decision. Anyhow credit constraints must be taken care of and for a family to end up owning it is necessary not to be constrained. Let q represent the probability of not being credit constrained, or in other words of having access to the credit market. Assume that a family is not rationed if it meets a certain criteria mathematically expressed by $C_i\ \delta > z_i$, where C_i stands for family i-th's characteristics vector, δ are unknown parameters and z_i represents an error term reflecting excluded variables. Then the proability that family i is not rationed is given by:

$$q_i = \int_{-\infty}^{C_i \delta} \phi\left(\frac{z}{\sigma_z}\right) dz \qquad (5)$$

where it is assumed that z follows a normal distribution with zero mean and variance given by σ^2_z, which implies that $\phi(z)$ is a normal density and $C_i\ \delta = \delta_0 + \delta_1 C_{i1} + \delta_2 C_{i2} + ... + \delta_G C_{iG}$. Expressing (5) in cumulative terms:

$$q_i = \Phi\left(\frac{C_i\ \delta}{\sigma_z}\right) \qquad (6)$$

As was previously mentioned, 'q' will be used as reference for 'capability of owning' and 'p' for wanting to own. Thus the probability of observing family i as an owner simplifies to:

$$\pi_i = p_i\ q_i \qquad (7)$$

In any case the family will have a demand for housing services equation (h_{ij}), which can be derived from the indirect utility function V.

$$h_{ij} = h_j(P_{ji}, P_x, Y_i, \varepsilon_{ji}) \qquad j = O, R \qquad (8)$$

where ε_{ij} are error terms which will be assumed to be independent from e_{ji}, ε_{ij} and z_i. For the utility function in (1) and (2) a special case of the Gorman normal function is assumed:

$$V = \left(Y_i - \beta_1 P_{ji} - \beta_2 P_x\right) P_{ji}^{-\alpha} P_x^{-1+\alpha} \qquad (9)$$

Demand equations are given by:

$$H_i = \alpha Y_i + \beta_1 (1-\alpha) P_{ji} - \beta_2 \alpha P_{xi} + \varepsilon_i \qquad (10)$$

where P_{ji} equals P_{Oi} for those who buy and P_{Ri} for those who rent. It will be assumed that the error term follows a normal distribution with zero mean and variance given by σ^2_ε.

In order to estimate the parameters of the utility, the pure tenure choice function and the credit constraint functions maximum likelihood methods will be used. If f_{ij} is the likelihood for the demand equation, then the likelihood function, given a results vector is given by:

$$\left(\pi_i f_{iO}\right)^{\gamma_O} \left(\left(1-\pi_i\right) f_{iR}\right)^{\gamma_R}$$

where $\gamma_O = 1$ if the family owns and zero otherwise and $\gamma_R = 1$ if it rents and zero otherwise. If the n observations are ordered so that the first A include owners and from A on individuals rent, then the log of the likelihood function can be expressed as:

$$LLF = \sum_{i=1}^{A} \log \pi_i + \sum_{i=A+1}^{n} \log(1-\pi_i) + \sum_{i=1}^{A} \log f_{iO} + \sum_{i=A+1}^{n} \log f_{iR} \qquad (11)$$

so that the total function can be separated into discrete and continuous choices. Using (4) and (6) the discrete part of (11) can be specified as:

$$LLF_d = \sum_{i=1}^{A} \log(p_i q_i) + \sum_{i=A+1}^{n} \log(1-p_i q_i)$$

While the continuous part using (10) is given by:

$$LLF_c = -\frac{n}{2}\log 2\pi - \frac{1}{2} n \log \sigma^2_\varepsilon - \frac{1}{2}\sum_{i=1}^{A} \frac{1}{\sigma^2_\varepsilon}\left(H_i - \alpha Y_i - \beta_1 (1-\alpha) P_{Oi} + \beta_2 \alpha P_x\right)^2$$
$$- \frac{1}{2}\sum_{i=1}^{A} \frac{1}{\sigma^2_\varepsilon}\left(H_i - \alpha Y_i - \beta_1 (1-\alpha) P_R + \beta_2 \alpha P_x\right)^2$$

DATA AND RESULTS

The estimation of the previous model for the city of Santiago has used data coming from CASEN 2003. However it is necessary to use other sources to complete all the information required. The following equation specifies the way used to compute the capital price of a housing unit (one square meter) for the i-th family (P_{oi} ,):

$$P_{oi} = W_k (r + T_K + m^0 - \tilde{r}) - T_i r W_K$$

where W_K represents the average cost of a unit of capital in zone k, r is nominal interest rate, $\tilde{r}$ represents the inflation rate, m^0 stands for maintenance costs, T_K is the effective property tax in zone k and T_i represents marginal income tax rate. In simple terms, the firs part amounts for the brute cost of being an owner and the second takes care of discounts related to the tax system. Regarding zoning, Santiago has been divided in 5 areas and housing capital prices for each zone has been calculated from official registers in public real estate bookkeepers. The inflation rate has been set equal to 3%, nominal interest rate reaches 6.43 and maintenance costs reach 0.0075. Finally, renting prices (P_{ri}) have been computed from newspaper adds in "El Mercurio" for November 2003, when CASEN 2003 took place.

In order to complete the database a variable computing housing expenditure is required. This information is provided by the Survey, since it asks individuals the rent they pay if such is the case and provides a calculation for the rent that owners would pay should they rent.

Notice that in order to complete the estimation of (11) a specification for the rationing equation is required. Equation (12) below provides it.

$$C_i \delta = \delta_0 + \delta_1 \text{ Work}_i + \delta_2 \text{ Income}_i + \delta_3 \text{ Civil Status}_i + \delta_4 \text{ Age}_i + \delta_5 \text{ Sex}_{i.} + \delta_6 \text{ Subsidies}_{i.} \quad (12)$$

Variables Income, Civil Status (1= married), Age and Sex (1= male) are self-explanatory, Work is a dummy that takes a positive value when the most important provider of the household declares to be employed and Subsidies takes into consideration if the i-th family has been aided by public assistance to acquire a house. Remind that this last variable is required as was explicitly shown in the stylized facts section. Table 1 reports estimated coefficients of (11) with a rationing equation given by (12).

Table 1. Basic results

Variable		Coeficients	Standard desviation	z statistic
Rationing equation	Work	0.720	0.110	6.529
	Income	0.000936	0.000	5.691
	Civil Status	0.715	0.118	6.078
	Age	0.020	0.004	5.074
	Sex	0.340	0.132	2.576
	Subsidies	6.970	109.058	0.064
	Constant	-3.073	0.316	-9.740
Demand Parameters	α	0.021	0.000	22.31
	β_1	0.548	0.026	21.47
	β_2	-0.002	0.001	-2.02

Number of observations: 2762 (1520 owners, 1242 renters)
LLF: -1295,68

Table 2 reports marginal effects, that is they quantify the change in the probability of not being rationed when each variable changes in unit values. Thus, if income rises from 100 thousand to 200 thousand Chilean pesos, then the probability of not being rationed rises 1.84%. Aging one additional year increases the probability of not being rationed in 0.39%. Clearly being a male, being employed and being married increase the probability of accessing the credit market.

Table 2. Marginal effects

Variables	Marginal Effects
Work	14.15%
Income*	1.84%
Civil Status	14.05%
Age	0.39%
Sex	6.69%

*For every 100 thousand Chilean pesos of income increase

Finally, the demand equation allows for the possibility of calculating income and price elasticities. The first one results after multiplying the estimate of α times s^{-1}, where s represents the fraction of housing expenditures in total income. Since that estimate in the sample is around 10%, income elasticity results in a figure of 0.21, below that of 0.32 reported by Henderson and Iaonnides (1986) for the U.S. Price elasticity results from solving: $\beta_1 (1-\alpha)-1$, which amounts to -0.45 for the Chilean case, more inelastic than the -0.8 reported by the same authors for the U.S.

SYNTHESIS

The main goal of this paper was to provide an estimation of housing demand and credit constraints for the case of the capital city in a developing country. Housing tenure choice decision was estimated using a micro-founded econometric model and maximum likelihood techniques. As stylized facts anticipated, when controlling for public subsidies, income results in a variable that conditions access to the hosing market. Specifically, when it rises 100 thousand Chilean pesos, the probability of being able to buy a house is 1.84% higher. Being older, male, married and with a stable job also affect positively the probability of not being credit constrained.

Estimated elasticities are not far from those reported for the U.S. Chile appears to have a more inelastic price elasticity, which may be related to the fact that people may have an implicit tendency to own. As was previously mentioned, in countries with risky financial history a house may become the safest asset available, and the only, in fact, for poor families that do not access the financial market due to informational issues.

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Estimating Large Complex Projects

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Abstract
Managing large capital construction projects requires the coordination of a multitude of human, organizational, technical, and natural resources. Quite often, the engineering and construction complexities of such projects are overshadowed by economic, societal, and political challenges. The ramifications and effects, which result from differences between early project cost estimates and the bid price or the final project cost, are significant. Over the time span between the initiation of a project and the completion of construction many factors influence a project's final costs. This time span is normally several years in duration but for highly complex and technologically challenging projects, project duration can easily exceed a decade. Over that period, changes to the project scope often occur. The subject here is a presentation of strategies that support realistic cost estimating. Through literature review and interviews with transportation agencies in the U.S. and internationally the authors developed a database of the factors that are the root causes of cost estimation problems.

Keywords
Cost escalation, estimating, estimate management, estimating processes, project cost, project scope

INTRODUCTION

Project cost escalation is a major problem for government agencies. Over the time span between the initiation of a project and the completion of construction many factors influence a project's final costs. Over that period, substantial project scope changes often occur. During the early stages of a project many factors that influence project costs are not known, these could be such things as insufficient knowledge regarding the exact project location, environmental mitigation requirements, or work-hour restrictions. There are also other process type factors that often drive project cost estimate increases. These factors can include, for example, unforeseen engineering complexities and constructability issues, changes in economic and market conditions, changes in regulatory requirements, local governmental and stakeholder pressures, and a transformation of community expectations. Some researchers have stated that there are systemic problems in agency estimating processes, even to the point that purposeful underestimation of projects is common to gain project funding [Flyvbjerg, et al, (2002)]. The impact of all of these issues is compounded if there is a lack of human resources with appropriate training in cost estimation or an institutional lack of cost estimation management processes. The factors cited in previous research make it clear that there are distinct challenges related to cost estimation management and development of early project estimates. These challenges are:

- Difficulty in evaluating the quality and completeness of early project cost estimates;
- Difficulty in describing scope solutions for all issues early in project development;
- Difficulty in identifying major areas of variability and uncertainty in project scope and costs;
- Difficulty in tracking the cost impact of design changes that occurs between major cost estimates.

Many of governmental agencies are seeking to strengthen the economies of their countries by executing some very challenging projects. As examples, Peru has recently signed contracts for a 700 kilometer $613 million Trans-Oceanic and Panama is developing a master plan for constructing 3rd Lane Locks. This research and the objective of the paper is not to suggest wholesale changes to estimating processes, but rather provides a clear and concise collection of strategies that will result in improved cost estimate management.

STATE OF PRACTICE

Over 100 documents have been reviewed and summarized in preparing this paper. The documents consist of journal articles (63%), reports (12%), conference proceedings (12%), and other documents (presentations, summaries). The literature was analyzed with attention to cost estimating procedures and cost estimation management. The data collected from all of these sources permitted the identification of the root causes behind cost escalation and lack of project estimate consistency and accuracy. Specific estimating practices and cost management approaches were identified that led to the cataloging of estimating strategies.

COST ESCALATION FACTORS

Construction projects have a long history of underestimation [Federal-Aid (2003), Flyvbjerg, et al, (2002)]. The factors that lead to the underestimation of projects have been identified through a large number of studies and research projects. The factors driving underestimation of project costs can be divided by project development phases: planning, and execution. As defined here planning involves all project development phases prior to bidding including long-range planning, programming, advanced planning/preliminary design, and final design. Execution entails contract bidding, award, project construction, and closeout.

The factors that affect the estimate in each development phase are by nature internal and external. Factors that attribute to underestimation and that are controllable by the agency are internal, while factors existing outside the direct control of the agency are classified as external. This arrangement of factors is shown in Table 1. The Table has been constructed to provide an over arching summary of the factors that have been identified from many sources and a better understanding of how project estimates are effected. It is important to note that most of the factors point to "forces" that impact project scope and timing.

Table 1. Underestimation Factors

	Planning	Execution
Internal	• Bias • Delivery/Procurement Approach • Project Schedule Changes • Engineering and Construction Complexities • Scope Changes • Poor Estimating (errors and omissions) • Inconsistent Application of Contingencies	• Inconsistent application of Contingencies • Faulty Execution • Ambiguous Contract Provisions • Contract Document Conflicts
External	• Local Government Concerns and Requirements • Time Value of Money • Scope Creep • Market Conditions	• Local Government Concerns and Requirements • Unforeseen Events • Unforeseen Conditions • Market Conditions

PLANNING-INTERNAL

While numerous internal factors can lead to underestimation of project costs at the planning stages seven primary internal factors have been well documented: bias, delivery/procurement approach, project schedule changes, engineering and construction complexities, scope changes, poor estimating, and inconsistent application of contingencies. Each of these factors separately or in combination with others can cause significant project costs increases.

Bias is the demonstrated systematic tendency to be overly optimistic about key project parameters. It is often viewed as the purposeful underestimation of project costs in order to insure a project remains in the construction program. This underestimation of costs can arise from the estimators' identification with the agency's goals for maintaining a construction program [Akinci and Flscher (1998), Condon and Harman (2004), Hufschmidt and Gerin (1970), Pickrell (1992)].

Delivery/Procurement Approach effects the division of risk between the agency and the constructors, and when risk is shifted to a party who is unable to control a specific risk, project cost will likely increase. The decision regarding which project delivery approach, design-bid-build, design-build, or build-operate-transfer, and procurement methodology, low bid, best value, or qualifications based selection effects the transfer of project risks [Harbuck (2004), New Jersey (1999), Parsons (2002)].

Project Schedule Changes, particularly extensions, caused by budget constraints or design challenges can cause unanticipated increases in inflation cost even when the rate of inflation has been accurately predicted. It is best to think in terms of the time value of money and recognize that there are two components to the issue: 1) the inflation rate and 2) the timing of the expenditures [Board (2003), Booz·Allen (1995), Callahan (1998), Touran and Bolster (1994)].

Engineering and Construction Complexities caused by the project's location or purpose can make early design work very challenging and lead to internal coordination errors between project components. If these issues are not addressed cost increases are likely to occur (Board (2003), Booz·Allen (1995), Callahan (1998), Touran and Bolster (1994), Federal-Aid (2003)].

Scope Changes, which should be controllable by the agency, can lead to underestimation of project costs. Such changes may include modifications in project construction limits, modification of the design, or correction of key project item dimensions [Chang (2002), Semple et al (1994)].

Poor Estimating (errors and omissions) can also lead to project cost underestimation. Estimate documentation must be in a form that can be understood, checked, verified, and corrected. The foundation of a good estimate is the formats, procedures, and processes used to arrive at the cost [Arditi et al (1985), Carr (1989), Harbuck (2004), Merrow et al (1981), Merrow (1988)].

Inconsistent Application of Contingencies causes confusion as to exactly what is included in the line items of an estimate and what is covered by contingence amounts. Contingency funds are typically meant to cover a variety of *possible* events and problems that are not specifically identified or to account for a lack of project definition during the preparation of early planning estimates [Noor and Tichacek (2004), Ripley (2004), Association (1997)].

PLANNING-EXTERNAL

External factors that can lead to underestimation of project costs include local government concerns and requirements, rate of inflation, and market conditions. Again it is recognized that each of these factors can act separately or in combination with others to cause significant project costs increases.

Local Government Concerns and Requirements typically include mitigation of project effects and negotiated scope changes or additions. Actions by the agency are often required to alleviate perceived negative impacts of construction on the local societal environment as well as on the natural environment. The required accommodation is often unknown during the early stages of project development [Board (2003), Daniels 1998, Mackie and Preston, (1998), Schroeder (2000)].

Time Value of Money is a key factor in the underestimation of costs for many projects. The time value of money can adversely affect projects when 1) project estimates are not communicated in year-of-construction costs, 2) the project completion is delayed and therefore the cost is subject to inflation over a longer duration than anticipated and/or 3) the rate of inflation is greater than anticipated in the estimate [Akinci (1998), Arditi et al (1985), Board (2003), Booz·Allen (1995), Merrow (1988)].

Scope Creep is similar to changes in scope; however, these changes are usually the accumulation of minor scope changes. Projects seem to often grow naturally as the project progresses from inception through development to construction [Board (2003), Harbuck (2004), Mackie and Preston (1998)].

Market Conditions or changes in the macro economic environment can affect the costs of a project, particularly large projects. Typically, the risks associated with large projects are much greater, both for the agency and contractor, and that affects project costs. Inaccurate assessment of the market conditions can lead to incorrect project cost estimating [Summary of Independent Review (2002)].

EXECUTION-INTERNAL

Cost growth occurring during the construction of a project cannot be ignored and must be planned for when estimating a project. Internal factors that lead to the underestimation of project costs during the execution of a project stem from poor project management and design documents.

Inconsistent Application of Contingency can be both an internal factor contributing to underestimation during the planning stage and a contributor to cost overruns during the execution of the project [Noor and Tichacek (2004), Ripley (2004)].

Faulty Execution by the agency in managing a project can lead to project cost overruns. This factor can include the inability of the agency representatives to make timely decisions or actions, or provide information relative to the project, and failure to appreciate construction difficulties cause by coordination of connecting work or work responsibilities [Board (2003), Chang (2002)].

Ambiguous Contract Provisions dilute responsibility and cause misunderstanding between the agency and project constructors. The core assumptions underlying an estimate are confused by ambiguous contract provisions [Chang (2002), Harbuck (2004), Mackie (1998), Measuring (1998)].

Contract Document Conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework [Harbuck (2004), Mackie (1998), Measuring (1998)].

EXECUTION-EXTERNAL

External factors that lead to the underestimation of project costs during the execution of a project stem from those items that are primarily out of the control of the agencies.

Local Government Concerns and Requirements can affect the project costs during the execution phase. Similar to the effects during the planning phase, mitigation actions imposed by the local government, or environmental groups during the construction of a project can extend the project duration affecting inflation allowances or add direct cost. (Summary of Independent Review (2002), Woodrow (2002)].

Unforeseen Events are unanticipated and typically not controllable by the agency, occurrences such as floods, hurricanes, or other weather related incidents. Events controlled by third parties that are also unforeseen include terrorism, labor strikes, and changes in financial markets. These actions can have devastating consequences to project costs (Akinci 1998, Chang (2002)].

Unforeseen Conditions are notorious for causing cost overruns. Unknown soil conditions or contaminated soils can affect construction processes. Utilities are often present that were not described on the drawings. There are a multitude of problems that are simply unknown during the planning stage and which can increase project cost [Semple et al (1994), Transportation (1999)].

Market Conditions affect the project costs during the execution phase similar to the effects during the planning phase. Changing market conditions during the construction of a project that reduces the number of bidders, affects the labor force, and other related elements can disrupt the project schedule and budget [Board (2003), Chang (2002), Mackie (1998), Summary of Independent Review (2002)].

ESTIMATING STRATEGIES

Project estimates are made at various times during project development. An estimating strategy must correspond with the information available at the time the estimate is developed. Thus, certain types of estimating practices are used during the different project development phases. Cost engineering research has proven that the ability to influence and manage cost is greatest at the earliest stages in project development.

The statement has been made in many forums that "initial cost estimates are not reliable" [Transportation (1997)]. With increased size, complexity, and the introduction of new technology comes exponentially larger risk [Warrack (1993)]. This is a lesson that many agencies and their estimators have not fully learned. To produce accurate cost/schedule estimates agencies must develop strategies that address all of the major factors influencing project cost. Based on the identified problems it is recommended that agencies adhere to the following estimating strategies.

MANAGEMENT STRATEGY

Cost Containment Procedures – Develop a protocol for actions when costs are exceeded at milestones. These actions should include a justification for changes and approval of a revised budget if costs cannot be contained.

Approval Authority – Develop policies on required approvals for changes in scope, schedule, and cost as they occur throughout the project development process.

SCOPE/SCHEDULE STRATEGY

Scope Uncertainty – Develop a mechanism that clearly describes what is included in the project scope and schedule and what is not included, especially in relation to estimated project costs.

Scope Change Form – Develop a procedure that encourages the project team to document scope changes and scope creep such that their impact on cost and schedule can be evaluated and tracked.

RISK STRATEGY

Probabilistic Estimates – Consider the use of probabilistic estimates. Probabilistic estimates of cost or schedule can be performed using readily available software tools. These tools support additional analysis of the output variances and sensitivities to input factors.

Contingency – Contingency is often the most visible quantification of the project risk. It should directly reflect the status of the project scope definition and design completion. Simply using a typical contingency value (e.g., 10%) should be avoided when more information is known about the project. The major factors contributing to the project contingency should be included in a description of the contingency.

Contingent actions – Once specific risks have been identified and their potential impacts quantified, strategies, and tactics for dealing with these risks should be developed and prepared for possible implementation. One of the most important aspects of risk management is the development of potential contingent actions to mitigate or provide optimal paths to overcome identified risks.

DELIVERY AND PROCUREMENT METHOD STRATEGY

Alternative Procurement Methods – Consider alternatives to traditional low-bid procurement when value for money can be justified. For example, best-value procurement techniques have been successfully applied for highway and other public sector construction to attain more qualified contractors, more innovative solutions, and shorter construction times.

Packaging of Contracts – Develop appropriately sized projects for the available market. Understanding the impact of market competition is essential for developing an accurate estimate.

DOCUMENT QUALITY STRATEGY

Internal Reviews – Develop document review processes that can be matched to project complexity and which provide a thorough assessment of the completeness and accuracy of the work by individuals who are not directly responsible for the project (independent check and review). Internal document reviews should:

- Determine the practicality of the design concept;
- Determine the constructability of the design; and
- Verify that the data provided by others has been properly used and is still appropriate.

External Reviews - First-of-a-kind and technically-complex projects require a document review process that utilizes the most experienced professionals for the particular type of work envisioned. Expert teams composed of external professionals should be formed to assess document quality.

ESTIMATE QUALITY STRATEGY

Creation of Project Baseline – Create a project baseline of approved scope and resulting cost, then track all changes in project scope, schedule, and cost throughout project design. This allows for the tracking of project changes and a valid comparison for which the current project can be compared.
External Estimate Reviews – Establishment of an estimate review process, using external expert teams will aid in achieving estimate quality. The sharing of lessons learned should be encouraged particularly for first-of-a-kind projects involving technical complexity or unknowns.

EXTERNAL ISSUE STRATEGY

Approval Authority – Development of approval authority protocol as discussed in the Scope/Schedule Strategy will assist in dealing with external issues.

INTEGRITY STRATEGY

Estimate Reviews – Use estimate reviews as discussed in the Estimate Quality Strategy to provide objective opinions on project cost.

Public Disclosure – Develop consistent public disclosure processes that communicate project costs and associated uncertainty consistent with the level of engineering/design completion.

The use of these strategies will enhance the quality of agency estimates of project cost and scope.

CONCLUSION

The cost escalation factors that lead to project cost growth have been documented through a large number of studies and matched to changes in cost estimates. Each factor presents a challenge to any agency seeking to produce accurate project cost estimates. These factors can be mitigated through strategies that focus on controlling the possible effects of these factors. The eight global strategies presented here are aligned with the factors that cause project cost escalation on projects. The fundamental focus of achieving accurate cost estimates should be to use –Strategies–that address the causes of estimating problems.

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Proposed Methodology for Community-Based Infrastructure Projects

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Abstract
Community participation is considered as one of the key activities of local government development. The new role of communities in infrastructure projects is to act as a bridge between the governmental agencies and the individual households. Low-income groups are generally poor not only financially, but also weak in terms of their power to influence decision-making on matters relating to their livelihoods and development of services. They are often totally excluded from the government development processes of planning, budgeting and project implementation. There are many parties concerned with infrastructure development that should be involved in a systematic manner in the formation of public policies and local planning. This study proposes a methodology to deal with all involved parties in infrastructure projects and it is recommended that it be followed from the first phase of any project. The proposed methodology is based on the investigation of the best practices and lessons learned from projects implemented by different agencies in Palestine. It is recommended that municipalities should reshape the people's understanding of the role and capacity of municipalities and to develop new mechanisms to develop trust and transparent relations with communities.

Keywords
Community, municipality, infrastructure, methodology

INTRODUCTION

Low-income groups are generally poor not only financially, but also weak in terms of their power to influence decision-making on matters relating to their livelihoods and development of services. They are often totally excluded from the government development processes of planning, budgeting and project implementation. In the Gaza Strip environment there are several implementing agencies of infrastructure projects, namely ministries, municipalities and other Non-Governmental Organizations (NGOs) working in collaboration with ministries or municipalities. The projects are either financed by the implementing agency if a budget is available or as a contribution from a funding agency. The projects concerned are different in terms of their sectors and scales. In general, three factors may control and influence the form of involvement and relationships between partners:

- Project owner beliefs and guidelines;
- Project sector and scale, and
- Funding agency requirements.

The relationship between partners impacts on the project process during the various project phases of identification and prioritization, design and preparation of documents, construction and operation, in a number of ways. This paper reviews several case studies concerning implementing methodologies of municipal infrastructure projects taking into consideration different funding agencies working in the Gaza Strip. These include the Palestinian Economic Council for Development and Reconstruction (PECDAR), Save the Children Federation, and the United Nations Development Program (UNDP).

BACKGROUND

In some developing countries, community participation has only meant that poor people contribute in kind or in the form of the provision of labour without active participation in the planning or implementation processes (Jinchang, 1997). The success of meaningful community participation depends on the successful mobilization of communities that can engage with local government and assist it to meet people’s needs. Although the mobilization of professionals to participate on a voluntary basis seems a naïve expectation, it could substantially enhance the processes. Building the capacity of these structures is critical. This capacity building should focus on organization building and financial resources (Urban Sector Network, 2001).

The Government of National Unity in South Africa is committed to an integrated rural development strategy, which aims to eliminate poverty and create full employment by the year 2020 (Republic of South Africa, 1995). While the state is committed to infrastructure development, improvement in services and a facilitative environment for entrepreneurial and local economic development, it is up to rural people to make it work for them. The Government of South Africa is committed to basic levels of infrastructure development such as the provision of water, sanitation, access to schools and clinics, road development and provision of energy. All of these will reduce the burden of poverty in rural areas, and allow rural people to invest their time more productively and so contribute to national growth. The strategy emphasizes two processes:

- The need for rural people to set the agenda through the taking of active steps to involve themselves in local decision making through, or with, local government, and
- The accountability of those who draw up proposals for government spending, in service delivery and in infrastructure development, to ensure that funding is well spent through consideration of sustainability, through capacity building of local government and through drawing up and monitoring business plans, based on good information (Republic of South Africa, 1995).

In South Africa, current legislation requires public participation in integrated development planning processes. Community participation was introduced as one of the key activities of developmental local government. Emerging democratic municipalities must work with community-based organizations and non-governmental organizations to establish minimum conditions of good governance and to implement effective development projects.

STAKEHOLDERS IN INFRASTRUCTURE PROJECTS PLANNING AND IMPLEMENTATION

Internationally, several agencies are generally involved with the planning and implementation of infrastructure projects, namely the funding, implementing, and benefiting agencies. However, depending on the nature of the project the stakeholders' list could include other ministries or governmental agencies. On certain projects the community is also considered as one of the main stakeholders. The contractor and the consultant have roles and their contribution may affect relationships on and the progress of project. In most communities, individuals do not have the capacity to understand the difference among needs. The community wants are requests to be provided with all services, whereas needs are the urgent and essential services that are necessary to improve their living conditions. In some areas this is more complex than others and complicates coordination with local authorities, and ultimately leads the municipalities to neglect the communities' needs. The capacity building and awareness is highly recommended to identify the difference between willingness and needs. Wants are the community's requirements for development of necessary projects from their own perspective. Need is the actual necessity of the project; for instance, community is willing to develop water, wastewater and road networks, but the actual need is wastewater network. Messages may be distributed to individuals via mosques, schools and clinics by the communities' committees.

CURRENT PRACTICES AND LEVEL OF INVOLVEMENT

Targeted Agencies

This study deals with several funding agencies working in the Gaza Strip. The initial short list of agencies was modified during the course of the study as some agencies indicated that they were not willing to do so as they considered the issue to be philosophical and therefore confidential to their institutions. The study considers funding agencies and does not include any investigation of local ministries or municipalities. The benefiting agencies, namely ministries or municipalities, indicated their willingness to implement the projects according to the requirements of the funding agencies. Consequently, the funding agencies have the primary responsibility of identifying the stakeholders' relationships and level of involvement.

Level of Involvement (Role of Each Party)

The investigated funding agencies can be classified into two categories in terms of their funding procedures. The first category provides funds through the Ministry of Local Government (MOLG), the ministry allocates and distributes the funds to the local municipalities and finalizes the selection criteria of the targeted project sectors. In this category the ministry is the implementing agency of the projects. The second category targets a specified municipality or Government, the funding agency and the targeted party cooperate closely and prepare a memorandum of understanding, which includes project information and the implementing methodology.

Funding through the Ministry of Local Government

The World Bank is one of the main parties classified under this category. The World Bank allocated funds to community development projects or emergency job creation projects through MOLG in cooperation with PECDRA as the implementing agency. Community Development Project Phase one and Phase two were implemented (CDP-I and CDP-II). During Al Aqsa Intifada, several emergency projects were implemented and others initiated. These include the: Emergency Response Program (ERSP) and Emergency Job Creation Program (EJCP-DANIDA) funded by DANIDA; Emergency Job Creation Program (EJCP-DFID) funded by DFID, and Emergency Job Creation Program (EJCP-IDB) funded by the Islamic Development Bank.

The methodology adopted for the CDP or EJCP projects required that municipalities propose projects based on the communities' needs and priorities. These were identified by communicating with the communities' representatives in the form of local community committees. Based on a review of various projects' documents and assessment reports the following can be concluded:

- The role of the community in CDP and EJCP projects is limited to the inception phase in terms of (identification and prioritization. The final decision relative to the setting of priorities rested with the respective municipality's Mayor and Councillors. No community role was reported during the other phases of the various projects - design, construction, and operation and maintenance. In certain cases the communities petitioned the municipality regarding the most important project in their area;
- The municipalities and PECDAR ignored the potential role of communities during the identification phase and informed communities regarding the final decision during preparation for field works;
- The communities made a part financial contribution to the CDP projects. However, no financial contribution was made to the EJCP project. On CDP projects, most of the benefiting municipalities only discussed issues with the community representatives, but refused to contribute financially because of the high level of poverty. Thus the municipalities paid the 10% contribution without negotiating directly with the communities to obtain approval of the funding or seeking of alternative sourcing of communities' contributions [EMCC, 2002];
- The municipalities do not have the capacity to find alternative sources for the communities' contributions. Only the municipality of Bait Lahya in Gaza Strip collects US$ 1 monthly from each household in the form of a surcharge added to water bills. This contribution was collected in a special account and used for the community contribution on the infrastructure development projects.
- All contacts and negotiation with the communities were through the municipalities and there was no direct relationship with the ministry and PECDAR as the implementing agency or World Bank as the funding agency.
- External auditors audited the community satisfaction, contribution, benefits and future willingness. The reports and social audits showed that the community satisfaction with the projects implemented and request more projects, mainly wastewater projects that have the first priority.

Funding directly to the Municipalities

The United Nations Development Program (UNDP) and Save the Children Foundation (SCF) provided funds for the development of local communities directly to the municipalities. There institutions requested municipalities to propose community-prioritized projects in order to achieve a higher level of community satisfaction. The required procedures varied between the two institutions, which both have different characteristics.

UNDP Projects

- In the period of 1997 to 1999, the UNDP implemented several projects considering the community satisfaction and mobilization before the start of implementation.
- In UNDP projects, no financial contribution was collected from the local communities;
- During the preparation phase, the UNDP and owners in the form of benefiting municipalities signed a Memorandum of Understanding. Under the section 'Operational Management', which lists the responsibilities of the owners, the issue of community mobilization was addressed through the presentation of the project objectives to the general [UNDP, 1999];
- The Public Relations' departments in the respective municipalities were responsible to present the objectives of the proposed projects to the local communities. The UNDP helped some municipalities to establish such departments and provided some assistance to develop staff capacity;
- On UNDP projects, communities were not introduced as one of the partners. However, the communities' acceptance was required to implement the projects and

From 2000 to date, the UNDP did not deem community mobilization as one of their requirements before implementation, but required that the communities accept the proposed projects and address the communities' basic needs.

SCF Projects

- In 1997, the SCF began working with local municipalities on community-based projects. SCF endeavoured to promote community participation in all phases of project implementation, and to develop the capacity of the municipalities in order to achieve this issue;
- Several 'water and sanitation' community-based projects were undertaken in the Gaza Strip and West Bank. The two projects undertaken in the Gaza Strip were implemented in Jabalia and Rafah;
- The evaluated reports and the final presentation workshop of best practices and lessons learned confirmed that the proposed outputs of these projects were achieved;
- The community committees had several roles during the project preparation and implementation phases. These roles were not limited to, but included :

- Participating in the preparing of awareness literature;
- Creating awareness using mosques, schools and clinics, and
- Facilitating communication with individuals, which helped to ensure smooth implementation of the project;

- A direct impact of the project and the methodology of implementation is that the capacity of the community committees and the municipality has been improved. The successful completion of the project has convinced the municipality of Rafah to adopt the community-based approach in its policies. The municipality of Rafah adopted the community-based methodology in projects executed by other agencies;
- Community committees' capacities were enhanced through their experience gained on the project, through communicating and the development of networking skills. Community committees made several contacts with other donors in order to implement projects in their areas and to achieve the integration of services. In general, the project have strengthened the links between community committees and other stakeholders;

- Community committees, men groups, women groups, and a child-to-child approach was adopted to communicate the project objectives and to increase the level of public acceptance and awareness, and
- The financial contributions were collected from the local communities after the awareness sessions and facilitated through continuous contact with community committees. Other community members covered the contributions of poor families. This is as a result of an understanding of the importance of the project and the role of the communities during the project phases.

Municipal opinions about community-based projects

Key municipal persons asked about the community-based projects said that, municipalities were not able to implement the projects smoothly because of the difficulty encountered in realising consistency amongst people or their representatives. Essentially consultation with and promotion of contributions by communities is only really possible during the identification and prioritization of projects. Involvement by communities during the implementation phase was also discouraged / or not welcomed because it would complicate project design and implementation [EMCC, 2002]. This was perceived to be attributable to a lack of experience in dealing with the community and implementing community-based projects. Furthermore, most municipalities did not have the capacity to deal with communities and their needs. Despite other key municipal persons having indicated their willingness to increase the level of community involvement during project implementation, during the actual implementation they neglected the communities' role.

In general the community contribution was welcomed and appreciated during the first stages of project development on CDP and EJCP projects. Some of the funding agencies consider the community as main project partners and that they should be involved in all the phases. With regard to the maintenance of projects, ultimately people's lack of interest and unwillingness to participate in maintaining the projects' services is merely a manifestation of their exclusion from all the processes of CDP projects. Furthermore, the municipalities in most areas did not prepare maintenance plans.

PROPOSED METHODOLOGY OF COMMUNITY-BASED PROJECTS

Based on an understanding of local community structures and the reviewing of the reports of different projects that were implemented using different methodologies a community-based methodology can be proposed. Before formulating a new approach, the following steps are proposed:

- The promotion of community participation should be during the planning, implementation, operation, maintenance and evaluation phases;
- The selection of a contract types should suite the community-based approach;
- Developing the capacity of municipalities to deal with community based projects;
- Adopting of community-based methodologies in the policies of municipalities, and
- Finalising the responsibility matrix including the community responsibilities during the first phases of the project development.

Figure 1 indicates the proposed approach and components relative to the agencies and project phases. The proposed approach strives to increase the participation of the community during all phases of projects. The approach can overcome the conflicts and misunderstanding within a community. It also establishes the necessary linkages with local government - the key objective is to include people in the process of policy-making and influencing how resources are to be used. Community participation can also generate a sense of responsibility and ownership, which increases a community's confidence in controlling its destiny and improves the sustainability of the development program.

For households to be fully involved, they must be fully informed, and their views and participation built into the program from an early stage. However, as with communities, it is important to recognize that all householders are not the same. Therefore, generalizations should be avoided. There is a difference between behaviour and attitudes of peoples in cities, villages or camps. The policy should aim at providing alternative choices and options to households that can then decide which they want, and increasing public awareness and capacity building in order to increase the level of interest amongst the people and their capacities. Levels of community participation may vary in the implementation of projects, depending on the technical and managerial capacity of the community, community committees and individuals.

Ignoring a community’s comments and complaints during the implementation of projects is considered the main cause of lack of cooperation and trust between people and the municipality’s staff and the project contractor. It is recommended that municipalities should reshape the people's understanding of the municipality’s role and capacity and then develop new mechanisms to engender trust and transparency in relation with the community. One of the proposed methods to increase the level of community contribution is through appropriate selection of contract types [Jinchang 1997]. Work may be contracted out to small and micro construction firms, either in the formal or informal sector.

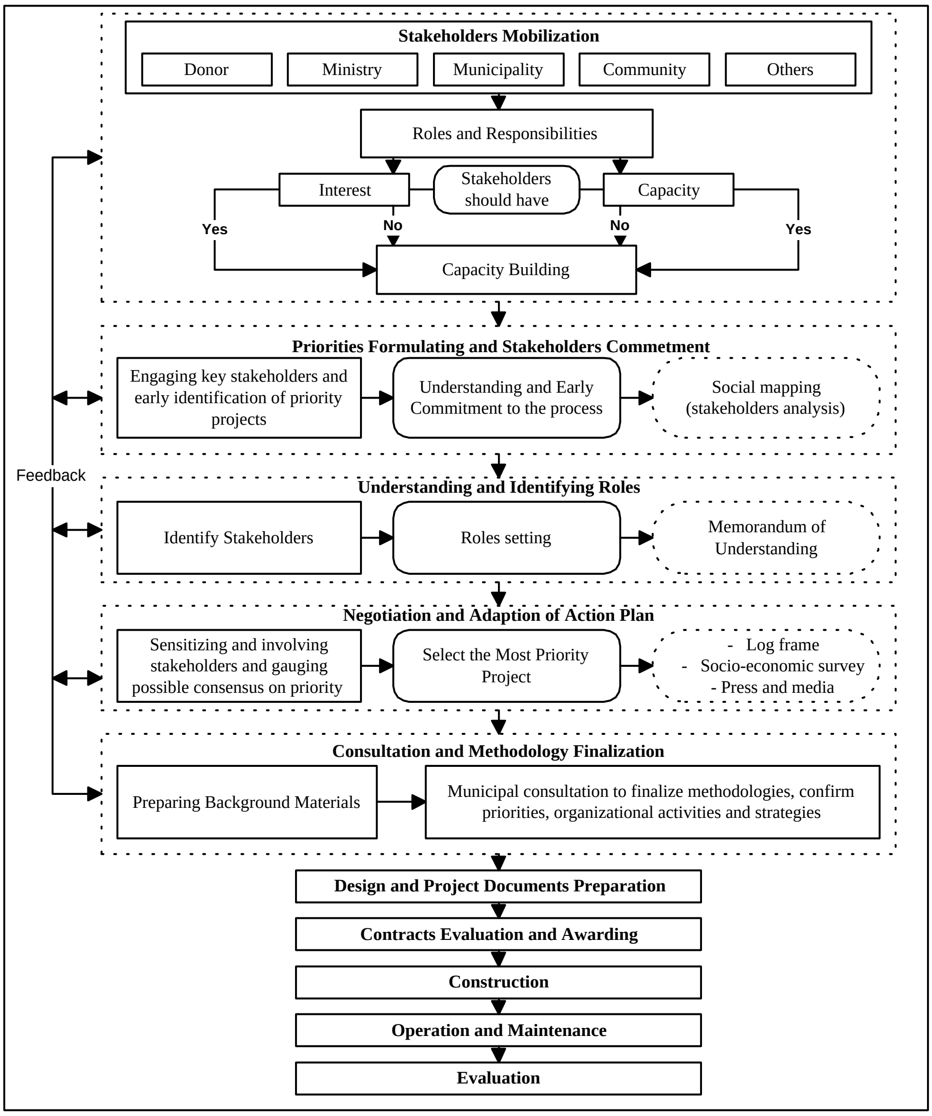

Figure 1 A proposed methodology leading to the adoption of community-based procedures in the Gaza Strip municipalities.

CONCLUSION AND RECOMMENDATIONS

The conclusions of the study are listed below:

1. The policies regarding community involvement in the identification of priorities and other phases of projects are neglected and / or not prevalent in most municipalities;
2. Some funding agencies require community participation during the different phases of projects as a pre-requisite for funding. Others view community participation as an

operational management issue and leave the responsibility of execution to the municipality without monitoring;

3. Key municipal persons indicate willingness to increase the level of community involvement during project implementation. However, during implementation they neglect the communities' role;
4. Municipalities exposed to community-based projects understand the importance of a community's contribution and the importance of making individuals aware of project objectives and the proposed methodology to achieve them. The communities' committees contribute to solving conflicts with individuals and liaise with communities to facilitate the implementation of projects, and support for the implementation agency;
5. The involvement of communities during project development ensures smooth implementation and facilitates coordination during construction. The objectives and proposed outputs of projects were achieved on the respective community-based projects, and
6. Community based projects enhance cooperation amongst people and ensure the collection of communities' contributions.

The following points are recommended:

1. The municipalities of local government should be involved and participate in any development activity and the development of methodologies for project implementation. This should avert conflicts between proposals submitted by municipalities to different funding agencies and to ensure the implementation of projects and their methodologies coincide with Ministry policies and regulations;
2. Contracts should be amended to promote increased community contribution;
3. For households to be fully involved, they must be fully informed, and their views and participation built into the program from an early stage;
4. Post project workshops should be conducted to present the lessons learned and communicate best practices;
5. Cooperation between donors is recommended and enhancement the communities should be empowered to deal with donors and other agencies;
6. Municipalities should reshape people's understanding of the role of municipalities and their capacity and develop new mechanisms to develop trust in the community and to promote transparency. This can be achieved by public meetings with communities, and periodic meetings with communities' committees to determine community requests and urgent needs;
7. Capacity building and awareness is recommended to determine the difference between willingness and needs. Messages can be communicated to individuals via mosques, schools and clinics by the communities' committees;
8. The budget allocated for the awareness activities should be maximized with special focus on communities' committees, men, women and children, and
9. Further training should be arranged for municipalities' staff on how to prepare a community-based project document.

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Dispute Resolution in Construction Projects in Gaza Strip: Practical Case Studies

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Abstract
Construction claims and disputes are a fact on large construction projects and not rare in small ones. Disputes between owners and contractors can be developed due to several reasons such as the nature of the work, its complexity, magnitude and many others. The resolution of these disputes can be costly and time-consuming ordeal for both owners and contractors. The purpose of this paper is to present and discuss two practical case studies where disputes between owners and contractors have been occurred. These case studies include: Gaza industrial estates - Storm water disposal system, and 220 KVA Gaza transmission project. These projects were funded by the World Bank, the European Investment Bank and Swedish Government. It is recommended that a clear policy concerning the force majeure clause should be presented; this policy should be discussed and negotiated with donors and contractors union. In addition, a clear enforceable law should be established regarding land compensation. Training courses in dispute resolution in construction management are also recommended.

Keywords
Dispute resolution, claims, construction, management.

INTRODUCTION

With the increasing political instability in Palestine, disputes in construction projects are inevitable. Skills in dispute resolution should be part of the tool kit of any practitioner in managerial position. The nature of the construction process means that the actual circumstances on constructions site will inevitably be different to the circumstances, which were anticipated at the start of the project. Site conditions and natural materials will vary, unexpected situations will arise, human beings will make mistakes and as a consequence of the problem situations that may occur, the project may be delayed and either the employer or the contractor will incur additional costs.

The party, which has suffered, may then try to recover his losses from the other party to the contract. However, additional costs and delays are rarely due to a single cause, which is clearly the liability of one party. Most problem situations are complex and contract can be interpreted so as place the liability for the additional costs on either party, dependent on the preference of the person concerned. Hence, in any construction project, there is a potential for differences of opinion, claims and disputes. Many of differences, claims and disputes can be resolved by discussion and negotiation between the people who are working on the site. The challenge for engineers and managers, on both sides of the dispute is to agree on a procedure which will resolve the problem with minimum disturbance to the project and the minimum cost to the parties to the contract (Totterdill, 2000). This paper presents and discusses two practical case studies, which were implemented in the Gaza Strip concerning dispute resolution.

CONSTRUCTION DISPUTE RESOLUTION

In today's complex construction projects, resolving dispute has become an inevitable part of a project manager's work. This includes a wide variety of activities ranging from the selection of a dispute resolution process to the participation in the actual negotiation. An understanding of the various forms of dispute resolution process and their critical factors will no doubt invaluable to project managers in handling disputes. Wilmot and Hocker (1998) defined conflict as "an expressed struggle between at least two interdependent parties who perceive incompatible goals, scarce resources, and interference from others in achieving their goals. Samuels (1996) described the parties involved in the construction process as " the owner, architect, engineers, the contactors, subcontractors, suppliers, individual workers, estimators, construction managers, and others when disputes develop, many if not all of these parties become involved ".

An opportunity for conflict can be found virtually anywhere in the construction industry or within a given project. Brandt and Murphy (2000) defined the reasons behind the conflict in construction industry as opportunities for conflict may be present in idealistic expectations by the owner; differences in contract interpretation between construction manager and contractor; design changes; scope changes; cost concerns; bid errors; environmental or community concerns; supply problems; inability to perform; differing site conditions; adverse weather; subcontractor performance problems; financing difficulties; work slowdowns and strikes; interpersonal conflicts; regulatory problems; lack of communication; coordination of multiple trades; and for other reasons.

It's well understood that World Bank operations cover most of the world countries with various local laws, the Bank procurement guide lines and standard bidding document reflects that variety by stressing in indicating the governing law and language as will as indicating the adjudicator. The following clauses were taken from the World Bank standard bidding documents for smaller contracts (World Bank standard bidding document).

24. Disputes
24.1 If the Contractor believes that a decision taken by the Project Manager was either outside the authority given to the Project Manager by the Contract or that the decision was wrongly taken, the decision shall be referred to the Adjudicator within 14 days of the notification of the Project Manager's decision.

25. Procedure for Disputes
25.1The Adjudicator shall give a decision in writing within 28 days of receipt of a notification of a dispute.

25.2 The Adjudicator shall be paid by the hour at the rate specified in the Bidding Data and Contract Data, together with reimbursable expenses of the types specified in the Contract Data, and the cost shall be divided equally between the Employer and the Contractor, whatever decision is reached by the Adjudicator. Either party may refer a decision of the Adjudicator to an Arbitrator within 28 days of the Adjudicator's written decision. If neither party refers the dispute to arbitration within the above 28 days, the Adjudicator's decision will be final and binding.

25.3 The arbitration shall be conducted in accordance with the arbitration procedure published by the institution named and in the place shown in the Contract Data.

26. Replacement of Adjudicator

26.1 Should the Adjudicator resign or die, or should the Employer and the Contractor agree that the Adjudicator is not functioning in accordance with the provisions of the Contract, a new Adjudicator will be jointly appointed by the Employer and the Contractor. In case of disagreement between the Employer and the Contractor, within 30 days, the Adjudicator shall be designated by the Appointing Authority designated in the Contract Data at the request of either party, within 14 days of receipt of such request.

Even though, for much formulation of construction documents is not an easy task. Cheung (1999) stated that drafting of construction contract documentation is not any easy task and typically involves the inclusion of provisions for anticipatory contingencies.

DISPUTE RESOLUTION ACCORDING TO WORLD BANK

World Bank believed that the best way to settle disputes is to avoid them by direct negotiations between parties at an early stage. If no solution is found, the parties should look for outside expert for conciliation which has been defined in the Law reform commission publication as**:**

A. Bringing together disputing parties so that they may agree on and begin procedures to resolve their dispute. The neutral third party acts as a facilitator only, and does not become involved with the substantive issues in dispute. That person may transmit settlement offers on behalf of each party.

B. A distinct process, which extends mediation to include elements of expert appraisal. The neutral third party, usually an expert in the subject area of the dispute, not only manages the negotiation, but also makes recommendations as to solutions. These usually are not binding but are used as a guide by the parties in reaching an agreement.

If the parties were not able to reach an agreement they may go to the litigation in court or to the arbitration which supposes to be mentioned in the World Bank bidding documents (Raman 2003). The arbitration clause as an arbitration clause is not solely an instrument of defining procedures to be followed in dispute settlement. It is very much a means of reminding parties that unless they try actively to sort out differences between themselves, formal arbitration is available to the party in distress and can provide him with the remedy sought within a reasonable amount of time and at a reasonable cost. Thus a proper arbitration clause should instill a spirit of urgency and conciliation in the parties.

CASE STUDIES

Case study 1: Gaza Industrial Estate- storm water disposal system

Project description
The project aims to collect the storm water generated from Gaza Industrial Estate (GIE) and the surrounding area into a collection basin, then to pump this water to Wadi El-katroon (been allocated as a natural filtration area by Ministry of Planning and International Cooperation (MOPIC). Wadi El-katroon is 3KM to the south of the GIE At the green line, consequently the rout of the pipe line designed to pass along side the road leading to Nitsareem settlement. World Bank committed itself to finance the design of the project while the European Investment Bank (EIB) financed the project execution.

Contractual relationship

Palestinian Water Authority (PWA) as a management unit for the (EIB) loan engaged into a unit price contract with X contracting company for the benefit of the Palestinian Industrial Estate and Free Zone Authority (PIEFZA). X was awarded this job amounting US$ 1,349,567 on 10/05/2000 due to competitive bidding. The company was just 0.1% less than the second bidder. The bid stipulated that the time specified for completion is 10 months. The contract was signed on 30/5/2000, after PWA assigned one of its employees as project manager, PIEFZA assigned TEAM engineering CO. to supervise the work. The site was handed to the contractor on 31/5/2000 and considered that as the start date of the contract. The contractor provided the needed resources to start the job on time.

Job work plan

The project consists of four major components these components were

1- The detention basin for collecting the storm water
2- Gravity pipeline no. II
3- Gravity pipeline no. III
4- Pressure force main.

Accordingly, the contractor methodology was to assign a group of resources to each component; the same administrative staff managed the four groups.

Details of the claim submitted by the contractor

At the beginning of the project, the contractor claimed that some contractual obligations of the owner were not completed such as unavailability of site, landowner disputes, incomplete design and lack of security coordination, which caused delay. At 30/10/2000 the project was frustrated by the project manager after the beginning of the Entifada, the project reports mentioned that the project completion level was 60% by the time of frustration, neither the project manager nor the contractor knows when they can restart the job. Several correspondences were exchanged between the contractor and the project manager regarding the job and the work condition at the site.

At 23/1/2001 the contractor sent a letter to the project manager requesting an approval for his due payment amounting US$ 129,609.05 reflecting:-

1- Balance of the work done.
2- Payment of full value of advance payment.
3- Releasing the 10% retention, and
4- Balance of unpaid materials on site.

At the same letter the contractor requested his legitimate claims on delays before and due to Entifada. These delays represent:

1- 77 days delay of detention basin before Entifada and 33 days during Entifada.
2- 119 days delay at gravity line no.2
3- 6.66 days delay at line no.3 due to extra depth.
4- 92 days delay at the pressure line

The delay period according to the contractor calculation is 325.66 days, which is more than the project period. Claims also include delay interest on late payment for the advance payment, progress payment No.3 and No.4 in addition to the cost of his extra cost during suspension from 30/10/2000 up to 20/1/2001 when he released his staff. The total amount of these claims was US$ 496,000. The project manager points were:

1. The contractor claim after the frustration is not considered according to clause no. 62 of the condition of contract which stated that (If the contract is frustrated by the outbreak of war or by any other event entirely outside the control of either the employer or the

contractor the Engineer is to certify that the contract has been frustrated. The contractor is to make the site safe and stop work as quickly as possible after receiving this certificate and is to be paid for all work carried out before receiving it and for any work carried out afterwards to which he was committed).

2. The consultant has assumed all of the works requires the same administration and managerial efforts. Bearing in mined that, there are 4 major components in the project (mentioned above), delay in any item will be granted 25% of the management and administration cost. Accordingly, the weight of any time delay claim will be 25%.
3. Due to utilization of labor and machinery in the other areas of the work, there will be no compensation against these categories.

Consequently, the consultant (TEAM) was requested by the project manager to review the claim submitted by the contractor and to comment on it, after reviewing the project documents, time schedule, daily report and equipment availability at the site, the consultant findings were illustrated in the following tables 1, 2, and 3:

A- For the period from 1/6/2000 to 28/9/2000

1- Detention basin Information

Activity	**Date**
Shop drawing approval	8/7/2000
Work started	15/7/2000
First stoppage due to landowner dispute	15/7/2000
Work restarted	14/8/2000
Second stoppage Due to Israeli army	28/9/2000
Stoppage period	30 days

Table 1: Detention basin claim

Contractor claim				**Consultant review**				
Claim	Duration	Daily cost (US$)	Total cost (US$)	Review	Duration	25% day	Daily cost (US$)	Total cost (US$)
Stoppage 1/6-17/8	77	2058	158466	Stoppage 15/7-14/8	30	7.5	864	6480
28/9-31/10	33	864	28512	None	None	None	None	None
Total	110		186978	30				6480

2- Gravity line No. II Information

Activity	**Date**
Shop drawing submittal	5/7/2000
Shop drawing approval	20/7/2000
Work started	24/7/2000
Work stoppage Due to land owner dispute	24/8/2000
Stoppage period	36 days

Table 2: Gravity line No. II

Contractor claim				**Consultant review**				
Claim	Duration	Daily cost (US$)	Total cost (US$)	Review	Duration	25% day	Daily cost (US$)	Total cost (US$)
Stoppage 1/6-3/7	33	686	22638	Stoppage 24/8-28/9	36	7.5	686	6174
6/8/2000	1	3000	3000					
9/8-24/8	15	1501	22515					
24/8-28/9	36	1501	54036					
28/9-31/10	33		30600					
Total	118		132789					6174

3- Gravity line No. III information

The contractor claim was about the change of the excavation depth which cost him an extra working days of 6.66 day with a cost of 295 US$/day , total cost is 1964.7 US$.

This particular claim was raised by the contractor at 20/05/2001, the project was frustrated at 30/10/2000, the project manager rejected this claim due to the fact that the parties were agreed at minute of meeting No.13 dated 29/8/2000 that any claim should be discussed on time directly with the project consultant, accordingly claims which are accepted to PWA are only those, which have, been agreed with the consultant on time.

4- Pressure line Information

Activity	**Date**
Shop drawing approval	21/6/2000
Work started at	24/6/2000
First stoppage due to land disputes	8/7/2000
Restart work	24/8/2000
Second stoppage	23/9/2000
Stoppage period	45 days

Table 3: Pressure line Claim

Contractor claim				**Consultant review**				
Claim	Duration	Daily cost (US$)	Total cost (US$)	Review	Duration	25% day	Daily cost (US$)	Total cost (US$)
Stoppage 8/7-6/9	59			Stoppage 8/7-24/8	46	11.5	1350	15525
30/9-31/10	32							
Total	91	1350	122850					15525

Claims due to late payments

The contractor claims that payments were late; accordingly he requested an interest rate due to these late payments (table 4).

Table 4: Claims due to late payments

Contractor				Owner
Payment	Date	Duration	Cost (US$)	Review
Advance payment	Submitted 16/5 Transferred 13/6	28 days	1035	Contract signed on 31/5, amount due on 10/6
Payment # 3	Delay up to 31/10	22 days	585	Submitted 21/9, due on 10/10.
Payment # 4	Delay up to 31/10	7 days	281	Submitted 14/10, due on 31/10
During intefada	Not justified		48,354	Not justified
Total			50,255	0

Claim summary

The claim summary is indicated in table 5.

Table 5: Claim Summary

Contractor		Consultant	
Total Delay	325.66	Total Delay	111
Total Cost	US$ 494,000	Total Cost	US$ 28,179

B- For the period from 1/10/2000 to 30/10/2000

Work progress has been affected seriously by the political situation; therefore the contractor was prevented to do some activities during the period 1/10/2000 to 31/10/2000 as scheduled. The only available activity was at gravity line no. II.

The contractor decision was to refer the case to the adjudicator named in the contract (Engineering Syndicate) which was accepted by the parties. The adjudication committee (consists of four engineers) held a first meeting with the contractor who agree to reduce the claim amount to 237,000 US$ instead of 496,000 US$ (due to clause no. 62 of the condition of contract as mentioned earlier), after that several hearing meetings were conducted with the parties to collect information and supporting documents. The adjudication committee requested that all the claims due to delays should be documented and in accordance with the clause of early warning of the condition of contract. Finally the adjudicator decision was to compensate the contractor with an amount of 27500 US$ which was accepted by the parties.

Comments:
In this case the first claim amount requested by the contractor was not justified due to the fact that he could not ask for any claim after the contract frustration according to the condition of contract but he has ignored this fact and calculated the amount of his claim as he is still in operation. The committee formed by the engineering syndicate made that condition clear to him so his claim has been reduced to the half after the first meeting. The committee depended on the available documents in the investigation and the contractor was not well prepared for the case. The consultant was doing his job as a professional and he was armed by a well-organized document. The minutes of meetings used as an important tool in this case. It's important for the

owners to be sure of the site availability before the contract awarding. A careful review of the design calculations, drawings, and specifications is an important tool to reduce the claims.

Case study 2: 220 KV Gaza transmission project

Project description
Several studies have been carried out to analyze a suitable transmission system in Gaza, taking into account both the Gaza power plant and the regional transmission system. The conclusion was that a 220 KV power transmission system should be established in Gaza with a north and a south substation in addition to a west substation at the power plant. Due to budget constraints imposed by Sida the possible available fund are limited to about half the amount required for the originally intended scope of the project. The reduced scope of the transmission system was:

1- Building the north s/s in Gaza north district close the green line.
2- Building the west s/s attached and integrated to the G.G.P.
3- Building on a 220 KV double circuit OH line to connect Gaza p/p (Gaza west s/s to the north s/s)

Contractual relationship
Swedish government committed itself to finance the project through Sida under the condition that the contractor should be a Swedish and the equipment should be at least 50% of Swedish origin. Therefore, four Swedish firms were short listed and invited for bidding, two of them were not interested in the project and they didn't submit their proposals while the other two firms enters into a joint venture and form one company for the project execution. Palestinian Energy Authority (PEA) enters into a contract negotiation with this joint venture, finally an agreement was made and the contract was signed with the joint venture company with an amount of $ 18 M.

The joint venture consist of ABB- switch Gear Company and Trans-electric (ELTEL) in order to supply and erect the needed equipment for the high voltage transmission line as will as the two sub-stations (Gaza north and Gaza west) . Swed power consulting agency was hired too as a consultant (to review the design and supervise the execution of the work) for the project with a contract cost of about $ 700,000. The rout of the over head line designed to pass along side the green line on a 35 **s**teel towers with a foundation of 100 M2 for each tower, the towers suppose to be erected at a private owned land with a total length of 13 KM. The project duration was 365 days.

Progress of the project
The company started the project at December, 1999 as scheduled, the north and west sub stations were built and the work in the transmission line started from the west (after huge conflict with the land owners), at October 2000 the Intifada started and the working area became unsafe according to the Swedish experts and technician in addition to that the Israeli army bombed the north substation, consequently, the Swedish workers traveled back to their country and the project activities have been stopped.

The dispute
The project contractor (ABB-Switch Gear) and the consultant **(**Swed Power**)** claimed that their employee and equipments were in stand still position for a long period of time because of the following reasons:

1- The political situation and its effect on the foreigner specialist
2- The delay of the arrival of the equipment due to Israeli restrictions.
3- The land owners refused to be compensated for their property.

4- In addition the equipments of the north sub station were damaged due to Israeli attacks which cause an additional cost of 150,000 $.

According to the above mentioned reasons the contactor as well as the consultant claimed that the situation at the area considered as a force majeure condition according to the Swedish law, accordingly they requested compensation. Swedish government has no objection to consider the case as a force majeure but they asked the Palestinian Energy Authority to negotiate the amount of compensation with the contractor and the consultant. PEA as a governmental organization refused to compensate the contractor under the force majeure clause according to PNA regulations, but they have agreed to compensate him against the damages and delay. PEA worked in several directions to settle the compensation issues:

1- Regarding the Swedish company they were requested to submit the documents which illustrate the damages and the delay in the project, after reviewing the submitted materials an agreement was conducted with the company to be compensated by an amount of 1,500,000 US$**,** and 300,000 $ for the consultant. This amount was paid to the company on August 2001, to encourage them to restart the work, while the compensation to complete the rest of the work still under negotiations.
2- For the landowners the energy authorities conducted several meeting with them and encourage most of them to accept the amount of compensation, which was suggested by a committee from the ministry of housing and other related agencies.

CONCLUSION AND RECOMMENDATIONS

Two case studies were presented and discussed with relations to claims and dispute resolutions. These projects were financed by international financing agencies. Disputes can be minimized or eliminated by reducing the numbers of claims which can be generated due to unlimited number of reasons such as: project delays, force majeure, unclear condition of contract, technical weaknesses and negligence. Land ownership disputes have generated claims in two case studies. The Palestinian Engineering Syndicate has been considered as an adjudicator in the discussed case studies that have been discussed in this paper. In the two demonstrated case studies the unstable political situation was the main reason for the occurrence of disputes. Clear conditions of contract can positively assist in dispute resolution. It is recommended that a clear policy regarding the force majeure clause should be discussed and negotiated with donors and contractors union. It should be noted that Gaza Strip and West Bank are not independent state yet, most of Palestinian land still under occupation. Even the part of the territories which are controlled by the Palestinian National Authority lies under the Israeli threats; for these reasons, a clause such a force majeure which can be applied during aggressive actions should be reconsidered. In addition, a clear enforceable law should be established regarding land compensation. Training courses in dispute resolution in construction management are also recommended.

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Successful Project Leadership: Understanding the Personality Traits of Leaders and Organizational Factors

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Abstract
The subject of leadership in large construction projects is explored in this research. Since large construction projects of today are complex, truly international, attracting several participants from all over the world from different cultural and ethnic backgrounds, role of leadership in success of project is vital. This study investigates the leadership styles which make the project leaders successful on large construction projects. The research also aims to find the significance of skills and personality traits of successful project leaders. The factors which can diminish the leader's influence on others and the organizational factors which make project leaders less effective are also studied. Results show that transformational leaders are thought to be more successful than transactional leaders. Moreover, communication, team work, personal and interpersonal and management skills have been rated relatively more important for success of project leaders.

Keywords
Successful leadership, leadership styles and behaviors, large construction projects, competence, effectiveness

INTRODUCTION

Gharahbaghi and McManus (2003) opine that leadership is vision, motivation, organization and action. Good leaders they observe, develop through a never ending process of self-analysis and utilization of education, training and experience to improve. Leadership is the ability to take people and move them forward [Ivey, 2002]. Thamhain (2004) supports the notion that leadership is a vital component of project collaboration and the art of creating a supportive work environment. He says that project leaders must understand all of the facets of project management system and its organizational environment for successful execution of projects. A project leader is a person who inspires, motivates, guides, coaches and mobilizes the team members and subordinates to follow so that aspirations and goals of the project can be achieved. Project leaders provide a vision of project outcomes as they clearly perceive the bigger picture of future and are proactive towards necessary changes.

Leadership styles vary across local cultures, the project leader's inherited culture, project environment and nature, different stages of project and contractual conditions of project. Several researchers have observed that there is a significant relationship between a project leader's professional qualification, leadership style, team composition and overall project performance [Hofstede (2001), Shane *et al.* (1995), Giritli and Oraz (2002) and Odusami *et al.* (2003)]. In view of Makiluko (2004), most of successful leaders in multicultural projects are task oriented and prefer relationship with parties since they tend to be able to maintain project team cohesion.

There is no doubt that one of the important subjects in today's management studies is leadership. However, at the same time, many people have not been able to articulate the idea of leadership in management studies regardless of much research and exploration in the area. Especially in construction industry, very limited work has been done on the topic of leadership [Giritli and Oraz (2002), Odusami *et al.* (2003)]. The current study is also an endeavor to discover the appropriate leadership styles for successful construction project leaders of large construction projects. The data was collected on the construction site of the Second Bangkok International Airport, the largest project in the history of Thailand, through a questionnaire survey.

The Role of Leadership for Project Success

Certain characteristics of leadership can enhance the chances for success in working with diverse project teams. Open style of management to increase trust, good sense of humor to diffuse potential misunderstandings, sincere interest in the staff individuals, good communication style, and understanding behavior of project manager are certainly good traits [Miller, 2000]. Belassi and Tukel (1996) have also emphasized on project manager's competence as critical factor affecting project planning, scheduling and communication. Long *et al.* (2004) have shown that 'competent project manager' has been ranked as the top critical success factor by owners, consultants and contractors in Vietnam. Muns and Bjeirmi (1996) have also supported the idea that success or failure of project management in certain project is highly dependent on the choice of project manager.

Project teams comprising of different gender and diverse cultural, ethnic and corporate backgrounds are becoming more common in the construction industry. A project in Thailand may be designed by a German firm, managed by an Italian firm, constructed by a joint venture of firms from different countries, using labor from Cambodia and Myanmar, and material suppliers from all over the world. Project leader fulfills the roles of facilitator, coordinator, motivator and politician on project [Briner *et al*., 1996]. Performing these complex jobs demands a competent leader who can effectively interact within and across several participant groups on the project. This challenging and complicated role of project manager has necessitated the development of more sophisticated approaches to managing the performance of project managers [Dainty *et al*., 2003].

Flowers (2002) emphasizes that possessing technical skills alone is not important for engineers. Developing the leadership skills is also vital for engineers if they want to contribute significantly to the future. A project manager should have a good understanding of all aspects, which evolve due to diversity of culture, religion, language, nationality, and region. He should also be able to communicate this understanding clearly among these clusters. All limitations and capabilities of project team members should be understandable to him. To build a spirit of cooperation and enthusiasm, considering these diversities and valuing them is not only necessary but also useful for the project leader. In general, subordinates follow the leader because of the respect, admiration, or caring for the individual, and his or her ideas [Daft, 2003].

Traits and Skills of Successful Project Leaders

Many papers and articles have been written on what skills and traits a leader should have to be successful on projects. Relationship of personality traits and performance of professionals has also been studied by various researchers [Carr et al., 2002 and Johnson and Singh, 1998]. Many researchers have put stress on personality traits. These personality traits can be honesty, sincerity, pride in accomplishments, adaptability, influence on others and competence [Goodale, 2005]. Ivey (2002) has presented five important features of leadership: integration, innovation, importance, intensity and integrity. There is a very thin line of differentiation between traits and skills. Sometimes individuals use their traits in a way that they become skills. For example, if a leader is influential on others, at times that is accomplished through personal and interpersonal skills, team skills, communication skills, management skills, organizational skills and technical skills. Therefore, leaders use their personality traits to strengthen their skills adequately.

Different researchers have laid emphasis on different skills according to their observations and findings. Some think that communication skills are more important for successful project leaders, some support personal, interpersonal skills and team skills. Some studies also favor the significance of organizational, management, and business skills. Though most of the researchers have given comparatively less importance to technical skills, considerable number of researchers is of the view that technical skills are also very important for a competent project leader. The present research is an effort to explore the skills which are vital for success of project leaders on large construction projects. In addition, very few researchers have discussed the negative points which contribute to failures of project leadership. These negative factors can be the characteristics of project leaders or/and the environment in which they operate. This is important to investigate all the factors which contribute negatively to the project outcomes.

Methodology

The research targets to explore the question "what are the key leadership traits of successful project leaders on large construction projects, and what personal traits and organizational factors make project leaders incompetent and ineffective?" Questionnaire surveys were conducted on project site of Suvarnabhumi Airport. Respondents were asked to rate the importance of attributes for success of project leaders on a five point scaling with 5="Very important" to 1="Not at all important". Different attributes of project leaders from the following major categories were presented to the respondents for rating:

1. Communication skills
2. Interpersonal skills
3. Team skills
4. Organizational skills
5. Management skills
6. Business skills
7. Technical skills
8. Specialty trades skills
9. Computer skills

Also, sixteen leadership behaviors were identified which fall under the main categories of leadership styles which are; transformational, transactional. These leadership behaviors were also presented for rating on the five point importance scale to explore which leadership behaviors are more important for successful project leaders. Additionally, lists of factors making project leaders incompetent and organizational factors making project leaders ineffective were also included in questionnaire surveys for investigation.

The Case Study Project

The Second Bangkok International Airport—Suvarnabhumi Airport—due to be completed in 2005 is a major undertaking, which will significantly enhance Thailand's economic and social development. Accordingly, the government has declared the construction of Suvarnabhumi Airport as a national priority. SBIA is the largest construction project in history of Thailand which has attracted numerous lead consultants, designers, contractors and suppliers from all over the world to contribute their expertise to this project.

Demographic Details of the Respondents

The data was collected on the site of the Second Bangkok International Airport. Project managers, deputy project managers, project engineers, and line managers were approached to respond to the questionnaires after a small interview. 78 questionnaires were received out of 80 questionnaires distributed, yielding a 97.5% response rate. The following five groups were approached for study:

Group 1: Client (NBIA: New Bangkok International Airport Company Limited)
Group 2: PMC (Project Management Consultants)
Group 3: CSCs (Construction Supervision Consultants)
Group 4: DCs (Design Consultants)
Group 5: CCs (Construction Contractors)

Hypothesis Testing

To test the hypothesis, ANOVA and Correlation tests were performed. ANOVA Test showed that 99 variables out of 102 confirmed no significant difference. Pearson's correlation test also illustrated that there is no significant difference between the opinions of groups.

Table 1. Results of Pair-Wise Correlation Tests

Participants	Client	PMC	CSC	Designer	Contractor
Client	1.000				
PMC	0.599**	1.000			
CSC	0.631**	0.783**	1.000		
Designer	0.391**	0.644**	0.745**	1.000	
Contractor	0.576**	0.694**	0.740**	0.580**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

Therefore, we accept the null hypothesis and conclude that perception of respondents remain similar on the subject of leadership for large construction projects, especially for the case study project.

Leadership Behaviors and Styles

The results in table 2, show that all respondent groups have given more or less similar ranking to the top ten leadership behaviors as whole.

Table 2. Ranking of Leadership Behaviors

Leadership behavior	Overall (78)		Client (7)		PMC (10)		CSC (40)		Designer (5)		Contractors (16)	
	M*	R*	M	R	M	R	M	R	M	R	M	R
Sets goals and work accordingly	4.41	1	3.86	10	4.40	3	4.40	1	4.40	2	4.69	1
Visionary	4.33	2	4.71	1	4.40	2	4.25	5	3.80	8	4.50	2
Manages conflicts	4.32	3	4.00	9	4.60	1	4.33	3	4.00	7	4.38	3
Maintains good relationships	4.27	4	4.57	2	4.00	6	4.38	2	4.40	4	4.00	8
Clarifies role	4.19	5	4.00	8	4.30	5	4.20	6	4.40	3	4.13	6
Facilitates Interaction	4.12	6	4.14	5	3.80	9	4.30	4	3.80	11	3.94	10
Result oriented and production Emphasis	4.08	7	4.00	7	3.80	8	4.13	7	4.00	5	4.19	5
Flexible and accommodative in decision making	4.04	8	4.29	3	4.30	4	3.98	9	4.00	6	3.94	9
Turns mistakes into learning	4.04	9	4.14	6	3.90	7	4.03	8	3.60	12	4.25	4
Controls through reporting and discipline	3.91	10	4.14	4	3.50	13	3.93	11	3.80	10	4.06	7
Leads by example	3.85	11	3.57	12	3.60	11	3.95	10	4.40	1	3.69	12
Rewards appropriately	3.67	12	3.57	13	3.20	15	3.80	12	3.40	15	3.75	11
Shares the personal matters of employees	3.42	13	3.86	11	3.50	12	3.45	13	3.80	9	3.00	15
Uses his authority and position power mostly	3.40	14	3.29	15	3.60	10	3.33	14	3.40	14	3.50	13
Respects elders	3.35	15	3.57	14	3.40	14	3.30	15	3.60	13	3.25	14
Uses punishment to correct mistakes	2.54	16	3.14	16	2.30	16	2.40	16	2.00	16	2.94	16

*Where M and R donate Mean and Rank respectively

The table clearly shows that leadership behaviors getting high score are mostly associated to personal power of the project leader and few are related to position power. This shows that transformational leaders are more successful having more power of personality rather than authority. Use of authority for success has been ranked tenth or below by all respondents giving evidence that being successful through personal power is more important. Very interestingly, ‘using punishment to correct mistakes’ has been ranked the lowest by all groups of respondents.

Factor Analysis for Leadership Behaviors

Factor analysis was performed to group the leadership behaviors and see the underlying relationships among these behaviors. There are 16 leadership behaviors about which the opinion of respondents was requested. Since sample size is 78, thus ratio of variables to sample size is nearly 1:5 which allows the use of factor analysis for making the groups out of these sixteen variables. Although sixteen variables were taken for initial tests to perform factor analysis, nevertheless, ‘result oriented and production emphasis’ and ‘maintains good relationships’ were removed from the list of variables as they did not meet the requirements of some initial tests. Following table shows the results of factor analysis through factor loadings of different variables.

Table 3. Factor Loading of Critical Success Factors

Key Leadership Behaviors	Components			
	1	2	3	4
Manages conflicts	0.785			
Turns mistakes into learning	0.701			
Facilitates Interaction	0.622			
Shares the personal matters of employees		0.758		
Respects elders		0.727		
Rewards appropriately			0.743	
Controls through (reporting and discipline)			0.680	
Leads by example				-0.685
Visionary				0.652

As a result of factor analysis, four components were formed for leadership behaviors. These components are shown in table 4. These four Rs, resolving, reverent rewarding, and revolutionary were named after the characteristics of variables forming the components.

Table 4. Factor Analysis Components for Leadership Behaviors

Related Variables	Principle Components			
	Component 1	Component 2	Component 3	Component 4
	Resolving	Reverent	Rewarding	Revolutionary
1	Manages conflicts	Shares the personal matters of employees	Rewards appropriately	Leads by example
2	Turns mistakes into learning	Respects elders	Controls through reporting and discipline	Visionary
3	Facilitates Interaction	--	--	--

Resolving

Constituents of this component are personal power of a leader which comes through expert and referent powers. Conflict management is an important task for project leader on construction sites and it is also vital for the success of projects. Likewise mistakes are also a part of work wherever people interact with each other. Learning from these mistakes and turning them to improvement in future is important for a project leader. A project leader is usually a project coordinator who facilitates the work among different team members. Assisting interaction among several team members, getting all of them on a track towards the success of project and resolving differences among them are characteristics of a project leader which facilitate the project objectives.

Reverent

Both of the constituent variables in this component are related to social and interpersonal attributes of project leader. They motivate the project leader to care after the subordinates and team members. It is true that personal life has a rational impact on professional life. If the project leader, who is also the boss shares the personal matters of subordinates, takes interest in solving the personal problems of their lives and gives them reasonable advice about the matters different from profession, this increases respect for boss in the hearts of subordinates and they are naturally motivated to follow the leader. There may be some colleagues and subordinates who are older than the project leader. Even being a boss and leader of team, if the leader pays due respect to elders, it also increases his deference among team members. It looks simple but it works and pays in the end.

Rewarding

This component consists of two variables: rewards appropriately and controls through reports and discipline. To be successful, the project leader needs to reward subordinates appropriately so that they can be motivated to work hard. Also, to create discipline, it is important to make sure that all reports and records are properly kept as required. Giving appropriate rewards at the right time is very important for motivating the staff. When they receive reward for their hard work, their motivation for future tasks increases and they also follow the instructions of their leader with more care and attention. Also, rewarding appropriately means that the leader appreciates the work of hardworking and committed team members making them to feel different from other team members. Other team members are also inspired by their rewarded fellows and show efficiency at work so that they can also be rewarded in the future.

Revolutionary

This component comprises of two variables: visionary and leads by example. Both of these variables emphasize that the project leader should be futurist, careful thinker and creative minded. He/she should be able to see farther ahead than others. Leaders should be responsive to changes and appreciate that what is important today may become outdated tomorrow. They should also be able to sense the future trend so that organizational and project strategy can be aligned with requirements of the future. Leaders should also set examples of good deeds so that others can follow them to bring improvements in work. Project leader being good in following all the principles and code of conduct on work place inspires the subordinates to follow these good examples. These two variables are complementary. If a project leader is visionary, he/she should also be able to set good examples and vice versa.

Different Skills

Respondents were asked to rank the importance of overall skills of Project Leaders. Table 6 shows the mean scores of these skills presented to the respondents. If we see the pattern of ranking, table 5 depicts high and significant correlations between the rank orders of overall skills by different respondent groups. Also all respondents have given high ranks to communication, management and team skills. Organizational skills have been ranked in the middle and of total nine groups except for the case of client who ranked organizational skills second. Interestingly, technical, business and specialty trades' skills have obtained lower scores overall and by all groups as well. Overall all results depict that a leader should be well conversant with communication, management, team and interpersonal skills. In addition, a successful project leader should have adequate knowledge of organizational, technical and business skills as well.

Table 5. Spearman Correlation Test for Overall Ranking of Skills

Participants	Client	PMC	CSC	Designer	Contractor
Client	1.000				
PMC	0.833**	1.000			
CSC	0.817**	0.933**	1.000		
Designer	0.767*	0.733*	0.833**	1.000	
Contractor	0.783*	0.833**	0.933**	0.867**	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 6. Different Skills of Successful Project Leaders

Different Skills	Overall (78)		Client (7)		PMC (10)		CSC (40)		Designer (5)		Contractors (16)	
	M*	R*	M	R	M	R	M	R	M	R	M	R
Communication	4.44	1	4.43	1	4.50	1	4.48	2	4.20	1	4.38	2
Management Skills	4.42	2	4.43	3	4.40	2	4.50	1	3.80	4	4.44	1
Team Skills	4.27	3	4.14	5	4.30	3	4.38	3	3.80	3	4.19	3
Interpersonal Skills	4.09	4	4.14	4	3.80	6	4.18	4	4.20	2	4.00	4
Organizational	4.08	5	4.43	2	4.30	4	4.13	5	3.60	6	3.81	6
Technical Skills	3.82	6	3.86	7	4.20	5	3.80	6	3.40	7	3.75	7
Business Skills	3.77	7	3.86	6	3.70	7	3.68	7	3.80	5	4.00	5
Computer Skills	3.35	8	3.43	9	3.40	8	3.45	8	3.20	8	3.06	9
Specialty trades Skills	3.33	9	3.71	8	3.30	9	3.35	9	3.00	9	3.25	8

*****Where M and R donate Mean and Rank respectively

Factors Contributing to Project Leaders' Incompetence

There are several positive characteristics of project leaders which make them effective at work place. Adopting these traits make the project leaders popular and respectful among their team members, colleagues and subordinates. However, there are also negative factors which make project leaders appear incompetent and less popular among their colleagues and subordinates due to which such project leaders emerge as relatively less successful on project. A list of these negative factors was prepared and presented to the respondents for rating. Results have been presented in the table 7. Results demonstrate that lack of personal power makes project leaders appear incompetent and ineffective at work place.

Table 7. Personal Factors Making Project Leaders Incompetent

Factors	Overall (78)		Client (7)		PMC (10)		CSC (40)		Designer (5)		Contractors (16)	
	M*	R*	M	R	M	R	M	R	M	R	M	R
Uses power wrongly	4.74	1	4.29	5	4.40	3	4.30	3	4.60	1	6.31	1
Poor communicator	4.35	2	4.29	4	4.40	2	4.30	2	4.40	3	4.44	2
Not experienced	4.28	3	4.43	3	4.50	1	4.38	1	4.20	6	3.88	8
Can't control complex situations	4.19	4	4.43	2	4.30	4	4.15	5	3.80	9	4.25	4
Blames others while facing failures	4.17	5	4.00	6	4.10	9	4.25	4	4.40	4	4.00	7
Can't stand up to top management	4.04	6	4.43	1	4.20	6	3.88	10	3.80	8	4.25	3
Poor motivator	4.01	7	3.57	10	4.20	5	4.05	7	4.00	7	4.00	6
Not self assured	3.99	8	3.57	7	4.10	7	3.95	8	4.20	5	4.13	5
Sets bad example	3.94	9	3.00	12	4.00	10	4.10	6	4.40	2	3.75	9
Does not consult while making decisions	3.83	10	3.57	9	3.80	11	3.95	9	3.80	10	3.69	11
Lacks technical expertise	3.76	11	3.57	8	4.10	8	3.75	12	3.60	12	3.69	10
Coming from hierarchical steps and lacks formal education	3.63	12	3.43	11	3.70	12	3.83	11	3.60	13	3.19	13
Not a good politician	3.54	13	3.00	13	3.60	13	3.63	13	3.80	11	3.44	12

*Where M and R donate Mean and Rank respectively

Organizational Factors Making Project Leaders Ineffective

There are factors associated with organizations which make the project leaders ineffective. Despite being superior at all schools of leadership, some organization factors impede the efforts of project leaders thereby making them to become helpless to bring any improvement or change. These factors prevail mostly at places where the whole organizational structure and system is so redundant that a single project leader cannot change the fate of project single-handedly. A list of twelve such factors was prepared and presented to the respondents for their opinion on a five point importance scale. The results have been shown in table 8.

Table 8. Organizational Factors Making Project Leaders Ineffective

Factors	Overall (78)		Client (7)		PMC (10)		CSC (40)		Designer (5)		Contractors (16)	
	M*	R*	M	R	M	R	M	R	M	R	M	R
Lack of resources	4.38	1	4.57	1	4.30	3	4.35	1	4.20	1	4.50	2
Lack of planning and control in organization	4.35	2	4.57	2	4.40	2	4.30	2	4.20	2	4.38	3
Organization don't have synergy between performance and strategic goals	4.18	3	4.43	3	4.70	1	4.00	4	3.80	6	4.31	4
Lack of upper management support	4.14	4	3.86	6	3.90	8	4.15	3	3.60	7	4.56	1
Lack of organizational communication	4.08	5	4.14	4	4.30	4	3.98	5	3.80	5	4.25	5
Organization don't have coordination among functional departments	3.92	6	3.86	7	4.00	7	3.93	6	4.00	4	3.88	7
Organizational staff is incompetent and inexperienced in the relevant field	3.85	7	3.14	11	4.10	5	3.90	7	3.60	8	3.94	6
Organizational politics hinders the success	3.82	8	4.00	5	3.90	9	3.78	10	4.00	3	3.75	9
Organizational staff is resistant to changes	3.76	9	3.43	9	4.00	6	3.80	8	3.20	10	3.81	8
Inconsistent reward system of organization	3.64	10	3.57	8	3.30	12	3.78	9	3.40	9	3.63	11
Language is a barrier to overall	3.45	11	3.43	10	3.40	11	3.40	11	3.20	11	3.69	10
Diversity of cultures in organization is a big problem	3.24	12	2.71	12	3.70	10	3.23	12	2.80	12	3.38	12

*Where M and R donate Mean and Rank respectively

Discussion of Findings

Leadership style can be derived from the behaviors ranked by respondents. Very clearly, people like to follow the leaders who have clear idea of future and a strong vision. In their opinion, instead of falling into disputes, a project leader should be able to solve problems and handle conflicts by developing good relationships. Attributes of transformational leaders have been ranked higher as compared to those of transactional leaders. Use of authority and punishment has been rated among the lowest rated leadership behaviors which mean that leaders can still get the job done by avoiding the use of authority and punishment but they should have good relationships and interaction with subordinates by clarifying their roles and being flexible in decision making. Also, four Rs of leadership also give a confidence of successful leadership on large construction projects. Therefore, a project leader with characteristics of four Rs that are resolving, reverent, rewarding and revolutionary has better chances of success on large construction projects.

It is evident from the results that successful project leaders need to be good in communication, personal and interpersonal, team and management skills. However, they should also develop necessary technical and organizational skills so that they can more competent on technical issues which can be confronted on projects.

Wrong use of power and authority, being a poor communicator, lacking experience in the relevant field, having poor control on complex situations and blaming others while facing failures, are top five factors indicative of incompetent leadership. On the other hand, not being a good politician, coming from hierarchical steps and lacking formal education and lacking technical expertise are not instrumented in making leaders incompetent.

Even if a leader is very good in the required skills for successful project leadership, some organizational factors may hinder success and act negatively to make the project leaders ineffective. The major organizational factors impeding leadership performance are: lack of resources, lack of planning and control, lack of synergy between performance and strategic goals, lack of upper management support and organizational communication. By contrast, diversity of language and culture in organization were thought to be least important factors likely to contribute to ineffective project leadership.

Conclusions

The research investigates the leadership styles of successful project leaders on large construction projects by ranking the most significant leadership behaviors. It is observed that transformational leaders have been considered more successful on large construction projects, particularly on the SBIA. Investigation of different skills of successful project leaders has emphasized on; communication skills, management skills, team skills and interpersonal skills. Research has also observed the personal and organizational factors causing the project leadership incompetent and ineffective on large construction projects. Study demonstrates that there is significant correlation among the opinion of various groups involved in large construction projects, about various subjects of leadership. Not only in rating but also in ranking of various variables of leadership subject, research observes a general agreement among the project stakeholders. Since the study has been conducted in Thailand, results are confined to local construction industry. General findings of leadership styles are inline with most of the studies conducted in construction in different parts of the world that is transformational leaders are considered more successful as compared to transactional leaders though exceptions may be there. However, personal and organizational factors making the construction project leaders incompetent may differ in different cultural contexts due to varying cultural norms and perspectives, structure and maturity level of local construction industry. Future studies may focus on how the personal and organizational factors engender incompetence of project leaders on large construction projects under diverse cultures.

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Project Management: Towards an Emphasis in the ´Conception-Operation` Interface

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Abstract
This paper highlights a point of view seldom researched in the project management field: a wider approach to its processes and participating players; regarding its whole life cycle and the integration between the stages of 'planning', 'conception', 'production' and, mainly, 'operation and maintenance'. The aim of this paper is to improve the performance of these projects, specifically of the hospitality sector, whose patterns must be established according to the values of the players in the process, above all, consumers and users, actually, the ones who use it during its operation. This approach results in the higher efficiency and effectiveness of projects in their initial phases; and, in addition, in the rise of its performance under use and operation. The methodology foresees theoretical revision considering the related subjects, which are critically examined together with results of case studies carried out in hotels in operation. Finally, we suggest a tool of integrated action that involves the 'management of technology' and 'quality planning' alongside the operation of related projects.

Keywords
Quality, quality planning, management of technology, building maintenance.

INTRODUCTION

Taking into account the contemporary paradigm regarding building construction and operation, we must emphasize a strand according to which its project is associated to an 'investment' put to the service of its users. Therefore building performance must be in line with the use it will be put to and contribute to productivity of organizations based in it. Inadequate planning or operation will bring about shortcomings that will set back activities performed in the building, as well as onuses that can be over and above the resources available to organizations involved, thus reducing intended benefits. Therefore, it can be concluded that adequate planning and execution are not enough to guarantee building's adaptability to use: appropriate use must be guaranteed, which involves planning its facilities operation. Along with this and also as a result of this, there is a need for consolidating, during conception, values associated with operation, since the considerations of data, setbacks and good practice at this stage are conveyed by important data on its conception, the steady increase in its performance, and, above all, the full satisfaction of its users. Within this context, the study focuses on how different phases of a hospitality project relate, mainly conception and operation. Such choice is justified by the relevance of building management to its performance itself and users satisfaction. To support this proposal, the methodology foresees theoretical revision on 'building projects construction and operation' and the interfaces involving these two stages; on 'building performance'; on 'quality planning' and on 'management of technology'; which are critically examined together with the results of case studies carried out in hotels in operation, using Post-Occupancy Evaluation (POE) tools. Finally, we suggest a tool of integrated action that involves the 'management of technology' and yhe 'quality planning' along the operation of the hospitality projects.

The concept of building construction and operation projects was born from its analogy with the other economic sectors, representing the non-routine innovations and problems that occur in any organization, distinct from its functional activities, "a temporary effort to create a unique product or service" [PMI, PMBOK (2002)], them being projects that repeat themselves but that, every time, have a different outcome form the previous ones. In this sense, the act of projecting a building configures a complex process characterized as "a whole succession of stages, generally with decisions taken from different hierarchical levels, great dispersion of responsibilities and low level of interaction among its players." [Melhado (1994)], all this added to the high risk of the process. The stages it undergoes are promotion and planning, conception, production, building operation and rehabilitation (or retrofit).

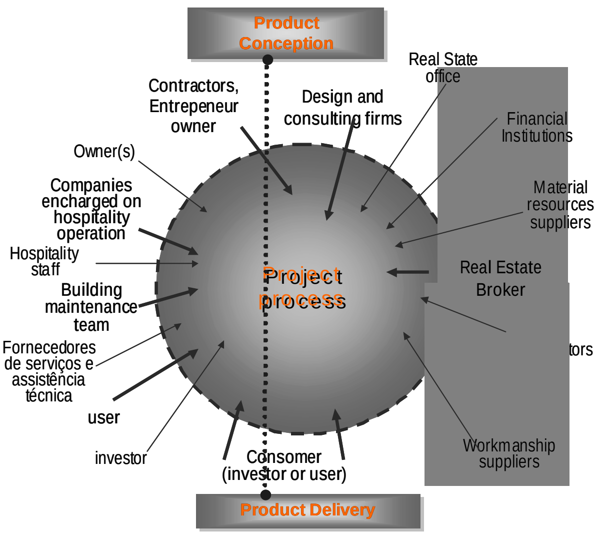
The **planning stage** is related to the choice and purchase of the plot, feasibility study, planning and promotion in the real estate market; and the players involved are developers, real estate agents and investors. The **conception stage** involves the activities related to the design and consultancy, aiming at defining the characteristics of the "product-building", the people in charge of which being the designers and consultants. The strategic role of this stage – that involves conception-operation interface – is concerned to the extent to which the decisions made by these people will affect the gains in the building operation and anticipate and solve critical problems when innovations are implemented, along with the reduced cost that configures its global cost; on the other hand, when these activities fail to go according to plan, this stage may become the main cause for the pathology in buildings, which can occur in about 40% of the cases [Josephson, Hammarlund (1999)]. **Production** is the construction of the building and its management, involving activities conducted in different ways, which take into account the levels of technological and managerial knowledge of the constructive processes, reflecting on the quality of the "product-building" and the satisfactory performance during its operation. In addition, we highlight the importance of the thread of building lifecycle flowing through both conception and production stages, with effective lines of communication between client, designer, contractor and those in charge of building operation and maintenance. Outdated administrative procedures often result in the various parties of building contract failing to appreciate the significance of other functions in the overall concept. The **operation stage** configures the time when the building is put to use, its conditions are adequate for occupation, use, and its facilities are performing [ABNT (1999)]. This stage sets the boundaries for its useful life, which involves the physical and functional durability of the construction, with due maintenance services. This demands flexibility and capacity to get up to date users needs as they appear [John et al (2001)]. The consumer and the user, respectively the one who buys and the one who uses the product, end up by footing the use and maintenance bill; and the people responsible for the performance of the building are merely the maintenance team that act upon building management methodologies [Gomes (1992)]. Such 'attributions' show that it is at this stage that the building will reveal the extent to which it is meeting the needs of its users, whereas the previous stages (conception and execution) condition their performance when they are being used.

Avoiding the occurrence of problems such as constructive pathologies or excessive consumption of resources costs little, but correcting the problem at the production stage is more expensive; but if the problem is transferred to the user the cost will be far higher. This sometimes causes frustration and annoyance to the maintenance personnel when they find lack of basic information about the building and its services. It is important to point out that the players are still pretty much concerned with the challenges at the planning, conception and production stages [Hendriks et al (2000), Gomes (1992), John&Cremonini (1989)]; over all, designers, who, unfortunately, rarely have a long-term interest in the buildings they have designed, tend to stand apart from operation and maintenance problems that came from bad design [Seeley, (1987)]. There is still a need of systematic analysis on the impact of the decisions taken at the initial stages as a result of operational needs, as well as the integration between the conception and operation stages. Closing the cycle, the end of the operation opens a **retrofit stage** that will involve remodeling and or demolishing [Hendriks et al (2000)].

It can be observed, after the brief description of the stages, that a project can be compared to a group of independent 'companies' working to a single end: the production and maintenance of a building. This idea is represented in Figure 1, which also illustrates 'two teams of players' involved in the lifecycle of a building: people who work in the planning, conception and production stages, and people who work during the operation stage. This creates a very difficult 'barrier' to overcome, thus preventing interaction between these two teams. It can be understood that closer interaction can be the first step towards the so desired integration between project stages.

Projects in the hospitality sector

Figure 1: Group of companies and players involved in the production process, delimitated by the project .



The hospitality sector is a subsystem of the tourism industry, which seeks to meet needs of people in transit and far from home for accommodation and shelter. According to Petrocchi (2003), such projects are systems that integrate multifunctional spaces around them, including events; in its totality this system must pursue the satisfaction of its clients. Receiving guests in a hotel involves comfortable, well dimensioned, well equipped suites, and pleasant ambience; added to this there are the administrative and industrial activities (catering and laundry), commercial activities (restaurants and shops), central systems (cold and hot water, energy, transport, air conditioning, etc), maintenance and a number of other activities related to events, entertainment and leisure. Here we emphasize the importance of the planning and the conception stages in these projects. The architectural design must bring about relevant and unique differences, thus contributing to project success in the market, besides the building's adequacy to the specific ends of the hospitality sector, which is translated into competitive advantages [Andrade *et al* (2003)]. Once the operation practices are taken into consideration at the moment it is conceived and executed, it also starts playing a decisive role in assuring the proper building performance and its users satisfaction.

The building performance in the hospitality sector

The high performance levels of the building and its capacity to meet the needs of its users are essential factors in the attribution of quality levels. In this sense, the idea of building performance must be understood as a technical vision, by which "the behavior of the building and its different parts is the result of the dynamic balance between the conditions to which it is exposed and how it is going to react to harmful agents" [Lichtenstein (1985)]. In this way, performance is associated with a building conceived to offer the user comfort, productivity, economy and safety, integrating it with the society and the environment around it; a system that involves a whole lifecycle.

It is important to emphasize the structural role played by users satisfaction in the performance of the buildings, whose evaluation occurs in a *rational and intuitive* way, when it is being used. *Rational* can be translated into safety (structural and intrusion-free), habitability, durability and economy, as described in ISO 6241 norm (International Standard Organization, 1984). *Intuitive* appropriates the Soen's concept [Soen, (1979)] of users satisfaction: "a clear statement of the items that comfort it, or by complaints against problems occurring in the unit, considered either in isolation or together".

Pursuing the success of the hospitality sector, by way of its management

Within a context of fierce competitiveness, the success of these projects is associated with the paradigm related to performance and the profits made from the operation, and capacity to meet the users demands. Actions to improve performance and quality have been taken; however, such actions are mainly focused on gaps identified in the *conception and production* stages, and not on the users needs. As a result, these studies led to ineffective building performance. And as these issues start to appear at the operation stage, they lead to lower users satisfaction levels. The decisions taken are mainly directed to construction costs to the detriment of the global building cost [Gomes (1992)]; buildability (easy and quick execution) thus overlooking the environmental impact the building may have [John et al (2001)] and its proper performance, functionality and maintainability (easiness to perform maintenance work) [Mesquita, Melhado (2003), Buoro et al (2003)].

This is the reason why we highlight two vital concepts in our proposal: *Quality and Technology*. According to Juran (1992) *Quality* must initially be understood as the combination of the product attributes, continuously improving, that behaves so as to perform in such a way as to meet the purposes it was meant for and go beyond satisfying clients. It is also important to mention the efficiency of the processes used in its production and operation [Gehany (1998)], close to the concept of aggregated value when such processes are coupled with a set of activities of technological nature, capable of adding value to the product. In Brazil, the movement for quality was characterized by a large-scale implementation of Quality Management Systems (QMS), which are the ultimate global management of quality policies for the organizational structure of the companies. In the case of the building construction segment it was restricted to the universe of property developers and some design company contractors. Santos (2003) made an assessment of the outcome of the implementation of QMS in this segment in different countries and concluded that such systems are tools that can improve companies performance, but only if coupled with other tools; the implementation of norms in an organization may lead to red tape, higher costs and can be time consuming; such norms are not adapted to the actual practice in the building construction segment; the people who implanted them are not involved in planning the project or its stages.

It can be observed that however important a tool like quality certification systems may be, they sometimes fail to yield satisfactory results; and, more often than not, integration between certification process and users real needs is incipient, and are not geared to their aims. Within this picture, if the idea is to ensure building quality, an exclusive plan ("definition of a desired future and effective means to attain it" [Ackoff (1975)]) for the project must be considered as an alternative along with QMSs. The application of the plan to product quality is understood as "the activity that sets quality goals and develops the products and processes necessary to the attainment of such goals ... demanded in order to meet customers needs, involving a series of universal steps" [Juran (1992)]; an approach shared by NBR ISO 10005 standard [ABNT (1997)]. In the case of buildings, Project Quality Planning (PQP) involves delimiting quality goals to its stages processes and to the product, coordinated in a systemic and harmonious way. Therefore PQP elaboration should formalize "collaboration among project (all) players in order to attain the goals foreseen, defining responsibilities, procedures and specific control as well as providing means for its management, thus maximizing the quality of the solutions and their results in terms of users satisfaction". [Melhado (2000)].

Technology concerns the sum of originally scientific knowledge, making it possible for lower-cost and better-quality products to be generated by means of increasingly sophisticated processes, representing "a whole set of knowledge, means and know-how, geared to some production or operation" [Ribault *et al* (1995)]; and including 'eight essential points': "products, production or operation processes, intellectual property, data processing, promise (of quality and confidence), people and their skills, project and planning, being a pioneer for financial gains" [Gehany (1995)]; the authors associate technology with the promise of competitiveness and the pursuance of greater productivity and yield in the use of the product. According to this, the technology applied to buildings must be understood as technology of products (materials and construction systems), of constructive processes (production technology), and building operation, comprehending the facilities and solutions for greater functionality and comfort for its users, and increased productivity for the organizations based on it.

This idea of technology gives rise to another issue that takes into account its interaction with integration with QMS. Based on the picture given, the question is whether QMSs and PQPs are really capable of guaranteeing buildings quality as a result of the use of technology in its lifecycle. Many times the implementation of a QMS proves to be unable to guarantee a 'technological culture' in the organization. If the system decides that product quality will be reached by means of traditional processes, or even crafted, so thus it will be done, and no technological gain will come from it. The result is the appearance of another gap in the context being described: *Owing to their particularities, products generated by building construction and operation projects sometimes fail to have a high aggregated value; such as innovation, technology and intelligence incorporated to buildings.* In view of the situation, it is wise to guarantee the adequate adoption of factors associated to the aggregation of value to project processes, whose particular characteristics are at the basis of the need for such values. However, since they are taken as 'abstract' their management is regarded as difficult, which will allow the organization that knows how to deal with them efficiently to stand out in the market. In building construction segment, such a factor has become a matter of survival, since the changes that have occurred in the last few years dictate that acquired experience is put to good use.

Within this picture, the management of technological knowledge, Management of Technology (MoT), represents a tool to be coupled with PQP, once it provides the *structure for the attainment and use of technology in an organization or project* by taking into account the factor necessary to guarantee the quality of their products. Ribault *et al* (1995) described it as "the process of development, choices, and diffusion of technology within the context of a project" and Gehany (1998) as "the configuration of the management system, policies and procedures, which defines the strategy and operationality of the project so that it achieves its aims". Therefore, we delimited as the universe of MoT, *the development and application of directions for projects, aiming at selecting, developing, applying and operationalizing technology in their processes, so as to add value to the building.*

CASE STUDIES

This item shows the partial results of four case studies concerning four construction projects in São Paulo, whose structure takes into account the elaboration of a comparative matrix (Table 1) including essential data on the projects, such as their characterization, QP and MoT practices (during operation stage) and building evaluation by its users. The criteria adopted for the case selection included the building time extent of operation, products of an economic nature geared to business tourism; whether it meets the criteria that delimit its minimum acceptable performance; and samples of hotels managed by three distinct hospitality companies. The tools used in the elaboration of the diagnosis were technical visits, semi-structured interviews with the main players involved and questionnaires to determine how the guests saw the performance of the building. [Ornstein; Romero (1992)].

A brief analysis of collected data lead to the following conclusions: location contributes to high occupation levels, with an annual average of above 70% in all cases (1); hotels run by different groups tend to find it more difficult to manage budgets and make decisions on maintenance activities (2); QP and MoT tools are not used, only QMS tool is used in the projects by company A, involving preventative maintenance procedures, and the development of an operation manual by company C (3); Projects 3 and 4 were not incorporated by their final owners, who were not involved in the conception stage and ended up by presenting a larger number of inadequate solutions (4); some solutions geared to buildability have not contributed to the maintainability or to the comfort of the users (5); some decisions that do not provides good performance in use, originated in the design stage, affect both the personnel (in terms of operationality) and the guests (implantation functionality and comfort) (6).

Table 01: Matrix of data on the projects studied and the results obtained.

	CHARACTERISTICS	QP & MoT	BUILDING MAINTENANCE	GUESTS
PROJECT 1: company A	Strategic location close to the city's arterial access road, near convention centers. Four years of operation, large sized and diversity of services offered. Company contracted by administration, belonging to one single investor, also responsible for the construction of the building.	No specific tools for building maintenance processes. The company implemented QMS (ISO 9000:2000) in their projects (economic class), whose scope comprehends accommodation and restoration services. Among its procedures, the management of resources foresees: a Preventative Maintenance Plan (PMP); maintenance and renovation of small materials; and maintenance of process software.	Economic category of the hotel demands reduced teams and investment on preventative maintenance, despite the great demand for the activity. More rigid criteria are needed to specify equipment; it was observed that some design solutions were inadequate to provide environmental comfort or maintainability. Constructive technologies gave priority to buildability.	Well evaluated, but assessment of indispensable requisites places it as presenting the worst performance of all. Dissatisfaction with air renovation, and internal acoustic insulation.
PROJECT 2: company A	Strategic location near busy airport and convention and commercial centers. Three years in operation, big-sized, diversified services offered. Company contracted by administration, the construction company (that built it) and a pool own the place.		SAME AS PROJECT 01. A pool of investors prevents decisions to be taken regarding the resources to be spent on maintenance. Inadequate design solutions jeopardize hotel's maintainability and functionality.	Well evaluated, but assessment of indispensable requisites places it as presenting the worst performance of all.
PROJECT 3 company B	Strategically located, near a famous university and hospitals. Three years in operation, small, offering basic hotel services. Company is owner of this project together with a pool of investors, and manages this project with relatively independence.	No QP or MoT tools. There is a pro project for manual maintenance and management of the building occurs upon the project manager's initiative.	The manager of the hotel, in charge of managing the building, regards its maintenance activities as quite easy. The exceptions are adequacy to budget and personnel available to perform tasks, and some inadequate solutions in the design.	Well evaluated, but assessment of indispensable hotel requisites indicates it as good.
PROJECT 4: company C	Strategically located in an important business and commercial micro region. Two years in operation, offering basic hotel services. Building used for commerce and the hotel, with separate entrances. Middle-sized, franchised, owned by a group of 8 big investors a pool holding 75 dwellings.	No QP or MoT tools, just a manual for preventative maintenance and programs for the operation of services, with procedures contributing to the maintenance of the building.	Difficulty to run budget foreseen for this activity and a reduced team to perform these tasks. Inadequate solutions in the project affect hotel's maintainability and functionality.	Good level of satisfaction. Just a few problems with the acoustic insulation of the units looking on the avenue.

There was a broad consensus that most of project's pathologies or inadequacies originate in decisions made at the design stage, whose control is associated with the estate developer or investor, who, even when they are the owners, tend to hold back investments at initial stages, thus bringing down building potential performance to levels below those initially expected and therefore increasing operational costs, to the detriment of operationality and customer satisfaction. In some cases these players show great concern with global costs and maintainability without, however, abandoning cost-benefit studies when adopting solutions. Another significant factor leading to inadequate solutions is that many designers lack technical experience of hotel buildings. To solve this problem, one of the solutions found by company A was to opt for working with professionals with experience of hospitality buildings, and develop a manual containing directions for designs, by taking into consideration maintainability and operationality of the implementation of the project: in the plot of land; construction technologies and specification of systems capable of reducing the consumption of resources, materials that contribute to maintainability and an architectural program inducing operationality. It is understood that effective and efficient design processes may stem from coordination by the very company, which, besides yielding a more transparent process, is more experienced in finding better solutions for the enterprise. Thence, the importance for companies, whose expertise includes hotel operations, to make more accurate decisions and providing feedback for new projects.

Considering guests' evaluation, and having in mind their stay (business), their level of satisfaction with the buildings performance is good. Location is the factor that mostly influenced hotel choice, whereas 'environmental comfort' and 'functionality' are factors that contribute to guest fidelity, since they are actually evaluated and configure requisites that results from decisions made during design stage. It is important to mention how the guests evaluated the services offered, which proved to be an implicit requisite during the evaluation. In projects 1 and 2, for which the company developed a manual with directions for designs, dissatisfaction with check in and check out services is latent, which led places such as Lobby to be put down as 'bad' or 'very poor'; a fact which was also observed in features such as restoration and governance. Contrary to the hypothesis at the beginning of research, guest satisfaction with hotel buildings is not associated with its performance in isolation; this is part and parcel of 'building performance + services rendering', both as result of adequate choices during the design process. Departing from the value attributed to services rendering, it is important to highlight the influence exerted by building maintenance: a building that offers adequate work conditions to its personnel will always lead to effective and efficient services. In all projects it was observed that the so desired implementation of software and tools to aid building management is faced against limited budgets, besides the need to dedicate more time to planning these activities. Finally, it was concluded from the answers given by project managers that the guest opinion is not taken into account in the elaboration of the project guidelines, and there is a need to provide feedback for new projects from the values of the operation.

Based on the initial reports and conclusions, it is important to point out that design process coordination conducted by companies operating in the hospitality sector (1), the establishment of directions for hospitality design processes (2), the qualification of the planners geared to the hospitality sector (3), and, the greater participation of agents involved in the building operation during design process (4) configure important actions taken to heighten the interface between the conception and operation stages.

CONCLUSION

This article, depicting the diversity and complexity involved in management of construction and operation in hospitality sector, highlights the need to give special attention to the operation stage, by considering building management and integration between 'operation and conception' as a feedback on the values of both stages. The results of the case studies confirm the initial hypothesis that values of their users fail to be adequately responded; and they reveal a lack of tools capable of improving the building performance in operation, such as QP or MoT; except in one of the cases, in which there were defined procedures for building maintenance. It was also noted that, despite some efforts made by hotel enterprises to change this situation, high levels of decision-making power of the developers and investors at conception stage while that maintainability does not appear as an important requisite along design process. In view of this picture, the proposal is to develop a model to be adopted in building operation, which will include MoT alongside the precepts of QP, defining a strategic tool capable of improving projects operationality and allowing greater integration in the interface 'operation-conception', due to wide participation of users opinions and the consideration of maintenance best practices, as well as the identification and removal of inadequate practices; until the moment when these values will be incorporated to management system and will be available in the moment of design conception, even throughout the participation of operation players in the design stage.

This proposal finds support in systemic approach, by which the analogous processes between these two tools undergo a 'fusion' process, based on MoT models, whose processes regards each one of those as being inherent to the scope of QP. The elements of this tool at the outset are building better performance, its maintainability, user satisfaction and the so desired feedback on the design. To conclude, if proposed model becomes more accurate, the scope to be covered in building operation must be established in conformity with the 'users voice, the action mechanisms to reach the aims must be defined and the proposed model controlled, particularly relating to the feedback to the conception stage. These issues are being developed in the PhD research that gave origin to this paper.

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Construction Project Planning and Control Integrated System Model

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Abstract
A conceptual model of an integrated system for construction project planning and control is presented in this paper. The model is the result from an exploratory study upon current construction project management practice in small and medium size companies in Southeast Mexico. The model provides a general solution to the problems detected in the study, based on two key sources: 1) the managers' opinion gathered from the study, and 2) project management theory. This model proposes guidelines to improve project management current practice in the region, through a better organization of the flow of information in all processes seeking to obtain an adequate "timely" decision making. The model addresses four areas: 1) project planning, 2) resources management (materials, labor, equipment, subcontracts and field overhead), 3) cost control and 4) cost forecasting. The model is described through: conceptual charts, flowcharts, and recommendations concerning the way the integrated model is expected to work. This model is the theoretical base for further development of computational tools, which eventually will help small and medium size companies to improve their effectiveness through the integration and automation of several managerial processes.

Keywords
Project planning, cost control, cost forecast, resource management.

INTRODUCTION

One of the main aspects that ensure the successful achievement of a construction project is comprehensive planning and control. However, there is evidence that small and medium size construction companies in Mexico (PYMES) dedicate great deal of effort to cost estimating, relegating the planning aspects of their projects. Lacking a thorough planning those firms are less likely to achieve comprehensive project control, and take timely decisions to keep projects on track. Such practice leads to overruns in both time and cost.

Many research studies have addressed that problem, showing the convenience to have cost and time integrated during the generation of plans. This goal could be achieved following also an integrated approach for the planning and control phases of the project. For instance, Syal *et al.*, [1992] proposed a "Construction Project Planning Process Model for Small – Medium Builders." However, even though other models have been developed to help PYMES [Syal *et al.*, 1992], the context and the objectives considered are quite different to the conditions faced by PYMES in developing countries.

Similar studies conducted at the School of Engineering of the Autonomous University of Yucatan (UADY) in the same topic resulted in an "Automated Cost Control Comprehensive System for PYMES," by González and Domínguez [1998], and a "Materials Management System Prototype for Large Low Cost Housing Developments," by González and Tirado [1998]. These studies, and others conducted in the region, share two main aspects: a) surveys administered to construction companies, aimed to know current project management practice, and their needs and requirements in that regard and b) system models proposals upon how to cope the problems found.

Alcudia [2002] updates the information through a new survey, addressing more specifically key aspects of the planning and control management functions. His study frames a conceptual model of an integrated system for construction project planning and control, and it is presented in this paper.

Alcudia's exploratory study revealed, among other issues, the following:

- Twenty two percent of the companies do not perform planning at all.
- Eighty six percent of the companies that do planning use Gantt charts as their solely planning tool. Those charts, however, are not obtained from network diagrams (CPM, PDM, or alike).
- Resource planning is done by only 64% of the companies and it is mainly used for bidding purposes. Once the companies get contracts, only 26% of them review their plans prior to the start of the execution phase, and only 10% during the construction phase.
- Sixty eight percent of the companies that do planning, namely 43.5% of the total population, use computing tools for it. However, most of them use a widely known computing program developed at UADY, which was designed mainly for the initial unit price cost analysis and cost estimate.

This leads to think that PYMES have to implement several modifications and adjustments to their current management practice in order to achieve a more comprehensive planning and control of their construction projects. Furthermore, the fact that less than half the companies use computers for their planning function leads to think that they lack a comprehensive system to handle the great amount of information usually generated during the project management processes.

To help PYMES to solve problems mentioned above, a conceptual model needs to be framed first. Then, the conceptual model should be the basis for future development of computational tools that will help PYMES to improve their effectiveness. As suggested by Liberatore *et al.* [2001], to maximize the impact on practice, development of new planning and control methods should include their integration into project management software. From the Software Engineering perspective, the model proposed here constitutes the stage of "requirements definition" in the incremental software development process [Mills, 1980 on Sommerville, 2002]. Currently, a computational system based on the model discussed here is under development at UADY [González *et al.*, 2005].

The improvements proposed in this model are primarily referred to the organization of the information flow, in all processes involved. The model addresses four main areas for improvement: 1) Project planning, 2) Resources Management: materials, labor, equipment, subcontracts and field overhead, 3) Cost Control, and 4) Cost and Time Forecasting.

As a starting point for the model's development, a "Basic Scenario" that is common to most of the interviewed companies was outlined, and a theoretical "Scheme of Departure" was proposed to frame the model's workspace.

MODEL'S DEVELOPMENT

Basic Scenario

According to Alcudia [2002], there is a common scenario for most PYMES that are about to start the execution phase of a project. It is important to consider this scenario for the model's development:

- The unit price scheme is the most common way for contracting construction projects in Mexico.
- Construction projects proposals are primarily valued on the merits of economic terms, neglecting other important aspects such as the proper planning of the project.
- As a result of the previous practice, contractors concentrate their effort in the integration of a bid primarily based on economic terms. This effort, as well as the company's experience can be summarized in a single document: the project's budget.
- The selected proposal becomes a contract for the winning company. However, such document does not contain enough information to manage the project properly.
- In general, most companies perform an inadequate and incomplete planning process, jeopardizing the execution of the project.

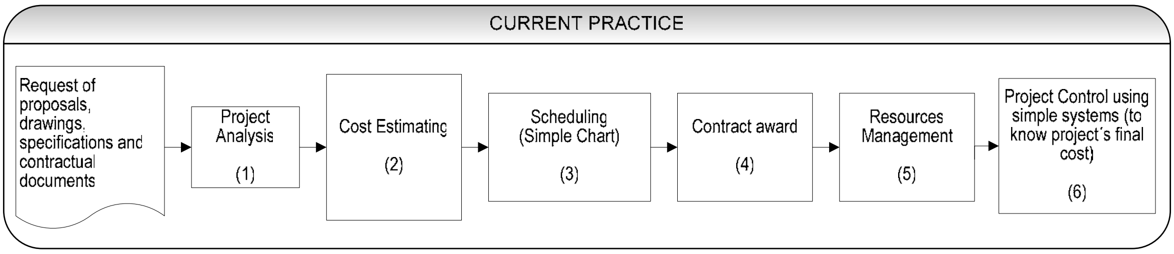
As a result, at the onset of project execution, most contractors only have the following documents to manage their projects: a) a *work contract* obtained primarily through a competitive bidding process, b) a detailed *cost estimate* for that contract, based on *unit prices*, c) a set of *drawings and specifications* and d) a *simple schedule* in the form of a Gantt's bar chart.

Since this scenario occurs shortly prior to the start of the project's execution, it is strongly recommended to PYMES that they carry out comprehensive programming and pre–control schemes. This is the only way to be able to implement an efficient cost control that subsequently leads to effective decisions making. It should be clear that the model has to be based on the unit price scheme. Furthermore, it should facilitate the use of information already used in the budgets such as labor and equipment productivity, and the resources resulting from the takeoffs.

Schemes of Departure

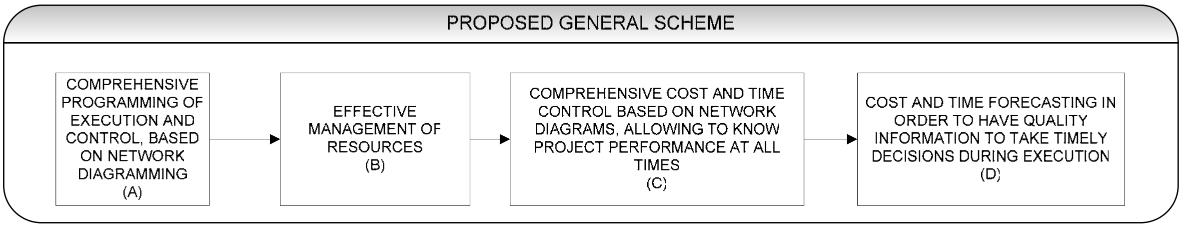
From Alcudia's exploratory study [2002], it was found that most PYMES carry out planning and control of their construction projects following the steps shown in Figure 1.

Figure 1. Current local practice on execution of construction projects



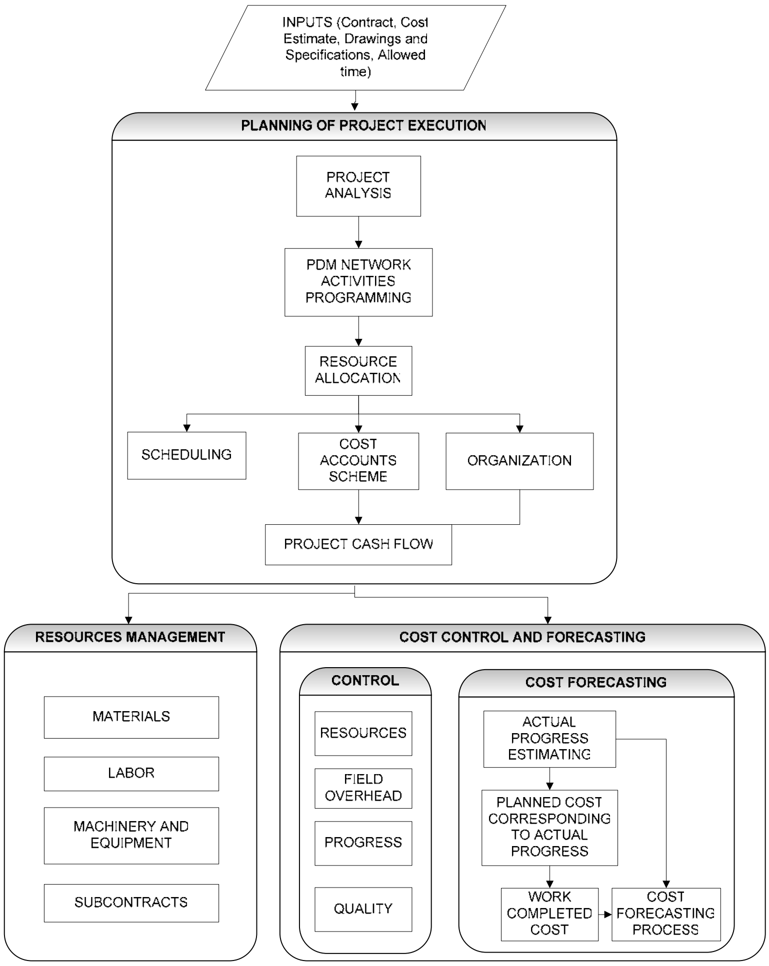
Since the purpose of this work is to improve current project management processes, the following new general steps are proposed: A, B, C, and D, shown in Figure 2. Those are suggested to substitute steps 5 and 6 in Figure 1.

Figure 2. General proposal for improvement in the execution of construction projects.



The results of the research clearly showed the authors that four major areas of improvement had to be included in any proposal: a) Comprehensive programming of the execution phase, b) Effective management of resources, c) Integration of cost and time control, and d) Cost forecasting. Therefore, the first scheme to approach the problem was based on the four aspects shown on Figure 3.

Figure 3. General scheme of the model system proposed.



Comprehensive programming of the execution phase

A basic premise for the development of the system is that most PYMES do not prepare a comprehensive planning based on networks scheduling. Therefore, that needs to be the starting point. From there, two additional key aspects have to be addressed: 1) resources management, and 2) project's performance control. Alcudia's survey reveals that constructors actually control their projects. However, such control does not come from a thorough planning process. This raises the following question: How can they implement an effective control if during planning time and cost are dealt separately? That characteristic has also been identified by Syal *et al.* in similar studies [1992]. Therefore, another important goal of the model should be the integration of cost and time for a more comprehensive an effective project management.

This starting phase is integrated by five different stages. Every stage is composed of several steps and requires a somehow lengthy description. Only a brief explanation is included in the following paragraphs. The reader could address the authors of this paper if requires further information.

The first and must important task the PYMES have to carry out is to make a *work plan* (program of activities) based on *network diagramming*. One of the first steps is to define the proper activities. Since the PYMES usually have close to one week from "notification of contract award" to the execution's starting date, they need to have beforehand the tools to prepare the programs in a very expedite way. PYMES also must take advantage of all the information gathered during the *cost estimate*, therefore they need tools for making quick references to this document, assuming it is in a digital media, while preparing the program in parallel. The outputs of this stage are: the *list of activities*, and their *durations*.

In the second stage, having the *list of activities*, PYMES have to establish the relationships among them, draw the activity network diagram, and do all computations. Following, they have to do adjustments to meet the contract's completion deadline. Finally, they will come up with the *general work plan*.

Once they have the work plan, it is extremely important to allocate all the resources from the cost estimate to the program of activities. Cost concepts definitions obtained from cost estimates based in a *unit price scheme* are many times far from activities definitions, however the same amount and cost of resources in cost estimates have to be allocated. For this step, PYMES need to take advantage of current information technologies. This proposal recommends the use of an electronic worksheet to integrate *planned resources* with activities (*planned time*). The electronic worksheet was named HEIAP in this work. This third stage's output is the integration of cost and time in digital media (HEIAP) and the "resource consumption schedules".

The next stage is to compute and analyze the project's cash flow and look for all the project's financing options. The HEIAP will also facilitate this task.

Making use of HEIAP, the final stage is to define a Cost Accounts Scheme (CAS). The organization of information in the HEIAP has, at least, three categories: *group of activities*, *activities*, *activity resources*. Thus, the CAS should have the same organization. The quantity and unit cost of every activity resource will be the basic information for every *cost account*.

This phase's general purpose is to have all documents ready before starting execution. These documents (in digital media, preferably) go from contract, drawings and specifications all the way to the CAS, construction's strategies and methods and "gathering info cards", including all sort of plans, programs and schedules. Only with a comprehensive planning strategy PYMES will be in a position to effectively manage the resources during project execution, establish and perform an integrated control, and take the best possible decisions relevant to the project [Russel *et al.*, 1997].

Effective resources management

Regarding the needs identified by Alcudia [2002], the following was deemed proper: a) the model should allow site data collection for analysis and decision making, and b) the model should be able to control schedules of needs, procurement, purchasing, and payment. In other words, it is necessary to establish an effective management of the "direct resources"; and it should be based on a planning process departing from network scheduling.

The "direct resources" this proposal recommends for effective management are: *materials*, *labor*, *machinery and equipment*, *subcontracts* and *field overhead*. On this regard, the authors consider that both the administrative and technical aspects have to be improved. The first aspect (actual management of resources) is the way to achieve the availability of resources on site with the following characteristics: "punctuality", "right amount" and "according to project's specifications". The technical aspect is also called "performance control" or "cost engineering"; this is the way to achieve that "actual costs" and "actual progress" be as close to "plans" as possible (programs, schedules, budgets, cash flow, etc.).

The proposed model includes a scheme for each resource mentioned. However, only the one for the materials is shown and explained in this paper as an example.

Materials Management

From the survey, interviewees mentioned they prefer quality materials, at competitive prices, and procured on time. This raises a contradiction, since to achieve the above it is mandatory to take care of several aspects that are currently neglected, or al least not considered enough, such as the preparation of a schedule for materials' procurement, considering both the capacity and reliability of suppliers and the financial resources available at the company. Moreover, such schedule should be flexible enough to accommodate potential contingencies.

A general scheme for materials management is shown on Figure 4. The starting point is the information coming from programs: "weekly requirements", "procurement" and "purchase and payments". The field engineer has a very important role in this phase; he has the additional function of checking and reporting actual materials consumption. The warehouse clerk may help with this task recording every material delivered to workers (*issued material notes- IMN*). It is important to understand that in every IMN has to be specified the activity or group of activities where the material will be used. This information is very valuable for the model, because it constitutes the "real costs" corresponding to the "actual progress", that have to be compared with "planned costs" and "planned progress" for evaluation of performance.

The field engineer can generate and manage this information easily with the help of the HEIAP. This should be done on a weekly basis (biweekly, at the most), in order to be able to detect deviations and to take timely decisions.

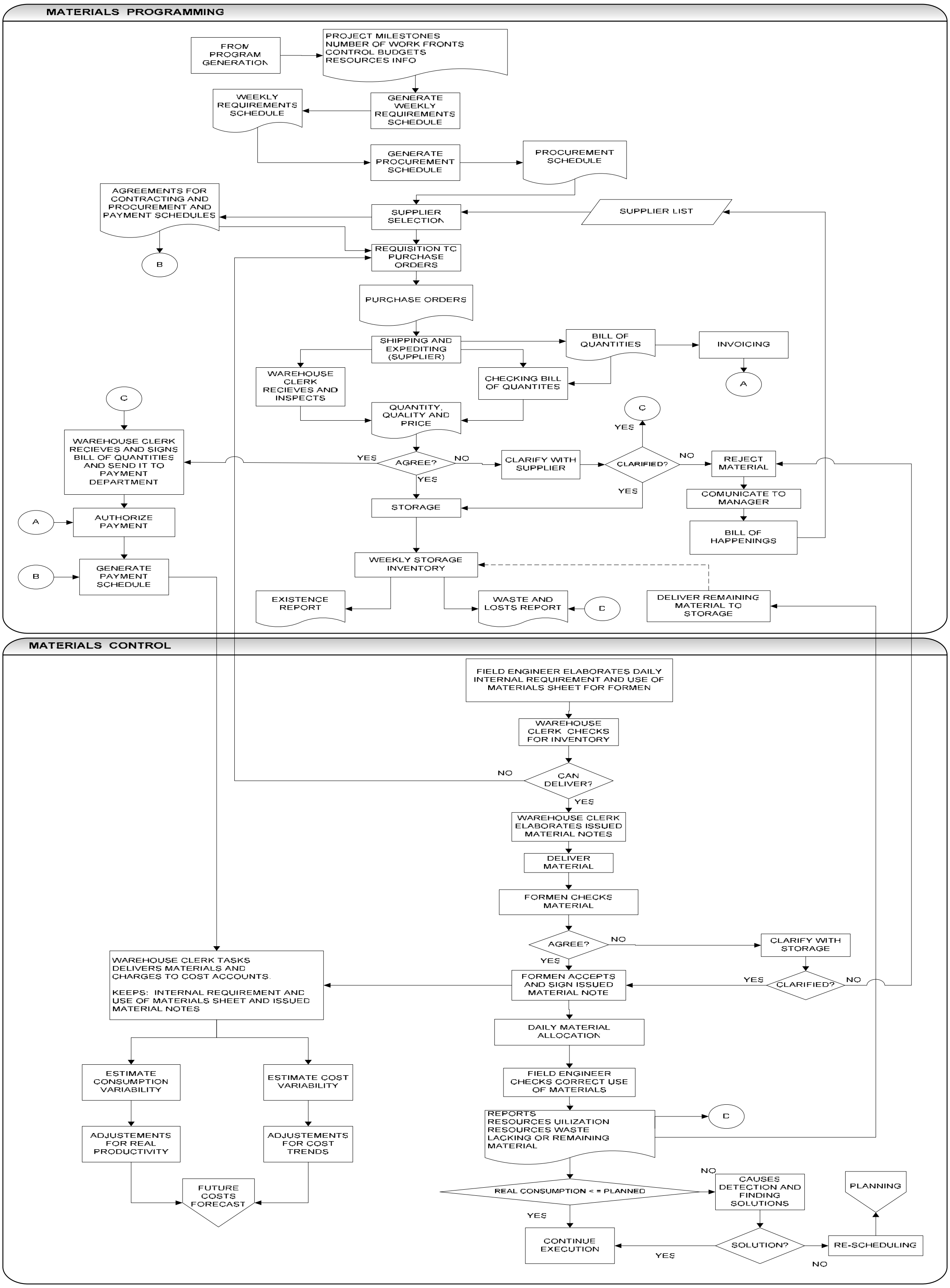

MATERIALS PROGRAMMING
FROM PROGRAM GENERATION
PROJECT MILESTONES
NUMBER OF WORK FRONTS
CONTROL BUDGETS
RESOURCES INFO
WEEKLY REQUIREMENTS SCHEDULE
GENERATE WEEKLY REQUIREMENTS SCHEDULE
GENERATE PROCUREMENT SCHEDULE
PROCUREMENT SCHEDULE
AGREEMENTS FOR CONTRACTING AND PROCUREMENT AND PAYMENT SCHEDULES
SUPPLIER SELECTION
SUPPLIER LIST
B
REQUISITION TO PURCHASE ORDERS
PURCHASE ORDERS
SHIPPING AND EXPEDITING (SUPPLIER)
BILL OF QUANTITIES
INVOICING
A
WAREHOUSE CLERK RECIEVES AND INSPECTS
CHECKING BILL OF QUANTITES
C
QUANTITY, QUALITY AND PRICE
C
YES
WAREHOUSE CLERK RECIEVES AND SIGNS BILL OF QUANTITIES AND SEND IT TO PAYMENT DEPARTMENT
YES
AGREE?
NO
CLARIFY WITH SUPPLIER
CLARIFIED?
NO
REJECT MATERIAL
YES
YES
COMUNICATE TO MANAGER
STORAGE
A
AUTHORIZE PAYMENT
BILL OF HAPPENINGS
B
GENERATE PAYMENT SCHEDULE
WEEKLY STORAGE INVENTORY
DELIVER REMAINING MATERIAL TO STORAGE
EXISTENCE REPORT
WASTE AND LOSTS REPORT
D
MATERIALS CONTROL
FIELD ENGINEER ELABORATES DAILY INTERNAL REQUIREMENT AND USE OF MATERIALS SHEET FOR FORMEN
WAREHOUSE CLERK CHECKS FOR INVENTORY
NO
CAN DELIVER?
YES
WAREHOUSE CLERK ELABORATES ISSUED MATERIAL NOTES
DELIVER MATERIAL
FORMEN CHECKS MATERIAL
AGREE?
NO
CLARIFY WITH STORAGE
YES
WAREHOUSE CLERK TASKS DELIVERS MATERIALS AND CHARGES TO COST ACCOUNTS.
KEEPS: INTERNAL REQUIREMENT AND USE OF MATERIALS SHEET AND ISSUED MATERIAL NOTES
FORMEN ACCEPTS AND SIGN ISSUED MATERIAL NOTE
YES
CLARIFIED?
NO
DAILY MATERIAL ALLOCATION
ESTIMATE CONSUMPTION VARIABILITY
ESTIMATE COST VARIABILITY
FIELD ENGINEER CHECKS CORRECT USE OF MATERIALS
REPORTS
RESOURCES UILIZATION
RESOURCES WASTE
LACKING OR REMAINING MATERIAL
D
ADJUSTEMENTS FOR REAL PRODUCTIVITY
ADJUSTEMENTS FOR COST TRENDS
FUTURE COSTS FORECAST
REAL CONSUMPTION < = PLANNED
NO
CAUSES DETECTION AND FINDING SOLUTIONS
PLANNING
YES
CONTINUE EXECUTION
YES
SOLUTION?
RE-SCHEDULING
NO

Figure 4. Materials Management Scheme

Cost control and forecasting

According to Alcudia [2002], PYMES generally have a clear idea of the final objectives for a good control system. Therefore, the implementation of such system is an answer not only to a requisite imposed by clients but to their own interest. However, regarding resources, there is not a common agreement upon what needs to be controlled. For instance some focus on "resources management" (namely, everything has to be managed) while others on "resources control" (Pareto's Law).

The cost control is a process that allows knowing actual performance of a project regarding cost and time. A great amount of data has to be gathered during the management of resources and then, it has to be organized and analyzed for comparison to plans. Then, it will possible to identify sources of variability, assess risk, and take pertinent decisions affecting the project performance [Isidore and Bock, 2002]. Cost forecasting is a fundamental tool in order to know "performance trends" (*future costs*). Since cost forecasting utilizes a large amount of information generated during the resources' control phase, the model addresses both phases simultaneously.

In this proposal, five different stages are recommended to carry out cost control and forecasting, as shown in Figure 5:

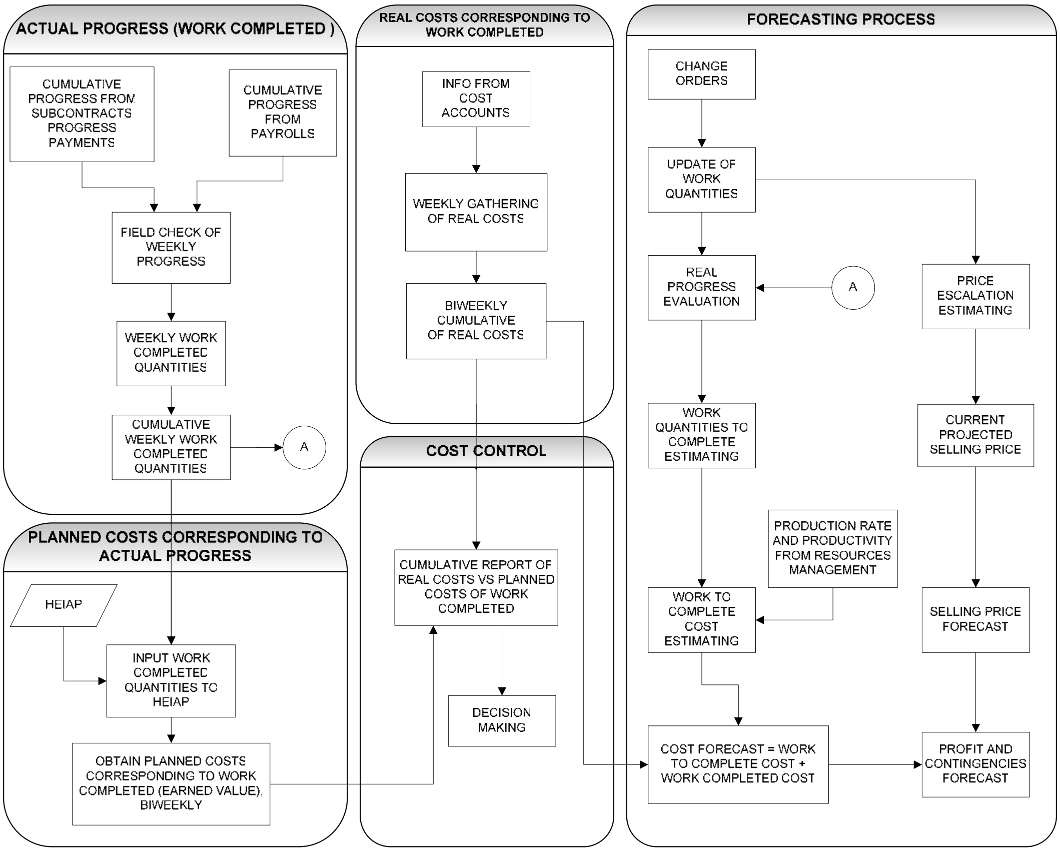
a) Determination of *actual progress*. From this point, it is straightforward to derive *work completed* up to date (or current work completed). It is advisable to carry out this task on a weekly basis.
b) Determination of *planned costs* according to actual progress (current value of project). It is easy to obtain by inputting actual progress on the HEIAP. This task must be done either weekly or every two weeks at the most.
c) Gathering of *real costs* corresponding to work completed. The inputting of real costs on the system must be done on daily or weekly basis, depending on the type of resource.
d) Reporting and evaluation of *cost control*. The reports must be prepared no more than every two weeks in order to take timely decisions.
e) *Cost forecasting*. The idea is to determine future cost trends and to infer final cost, profit, selling price, and actual contingencies, from project's forecasted completion date.

CONCLUSIONS

- Planning is addressed very lightly by PYMES. It is primarily based on past (undocumented) experiences and only occasionally is done trough a rigorous analysis of information.
- After winning a contract, PYMES do not dedicate enough time to prepare a comprehensive plan. Such planning is the basis for their control.
- A comprehensive model system to integrate time and cost, for planning and control purposes, was proposed to respond to the needs of the common problem scenario. The model incorporates valuable managers' opinions. It is aimed to be a guide for PYMES to prepare a comprehensive planning and pre-control process expeditiously; it should also be the basis for resource management, and cost and time control.

- It is very important to develop a computer program to help PYMES to carry out the tasks included in the model. This will make the model more attractive to PYMES. For an industry to survive in a very competitive market it must adopt emerging technologies to increase its efficiency.
- The model and the computer program will comprise an integrated system for planning and controlling construction projects.
- The system will require testing and validation, primarily by PYMES that expressed their willingness to participate in the research.
- The system should be flexible enough to be adapted to each company's needs.

Figure 5. Cost Control and Forecasting Scheme



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Eliminado: *Economies*
Eliminado: *Countries*

Design Planning and Control in Complex Projects and the reduction of information batch sizes

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Abstract
The integration between design and production planning and control has been pointed out as an essential issue to improve the product development process (PDP) in construction, specially in complex and fast projects which deal with high uncertainty. Due to the concurrency between design and production processes and the high interdependence and uncertainty in such projects, a mechanism used for the design process planning has been the reduction of information batch sizes. The objective of this paper is to propose some criteria and tools to support the reduction of design information batch sizes in construction projects. Two case studies were carried out in two projects developed by a construction company from Porto Alegre, south of Brazil. The main sources of data were participant observation in design and production planning meetings, analysis of design and other documents, production controls, and interviews with members of the design team. One of the main contributions of the paper is the use of a design mapping tool, which makes explicit the main interdependences among design batches, and the link between design and production planning.

Keywords
Product development, design planning and control, production management, concurrent engineering, information batch.

INTRODUCTION

The separation of design and construction has long been presented as one of the root problems of construction. Thus it is no wonder that great expectations have been attached to design-build procurement of construction projects, where these two stages are organizationally integrated from the outset [BALLARD and KOSKELA, 1998].

According to Anumba and Evbuomwan (1997), Concurrent Engineering (CE) is a concept which has come into being within the eighties, and has resulted from ever-increasing pressures on manufacturers to be more competitive in terms of product quality, cost, durability and others. This has been an area of growing interest in the construction industry, especially in projects that involve short duration, high uncertainty and complexity [Huovila *et al.* (1997), Koskela (2000), Codinhoto (2003)].

DESIGN PLANNING AND CONTROL

Traditionally, building design has been planned by the same methods used to program construction. These techniques do not allow the effect of variations and delays to be fully understood, due to the iterative nature of design. They typically monitor progress based upon the completion of drawing work and other design deliverables, as opposed to the availability of key pieces of information [Austin *et al.* (1999)].

According to Austin *et al.* (1998), such design process planning techniques have proved to be unsatisfactory due to the iterative nature of design and the complex interdependences amongst design disciplines, particularly in complex projects in which large multidisciplinary design teams are required.

Some previous initiatives have investigated the planning and control of design processes in construction. One of the most well known ones is the ADePT method (*Analytical Design Planning Technique)* developed by Loughborough University [Austin *et al.* (2000)], which adopts the DSM (Design Structure Matrix) as the core planning technique. The ADePT method proposes the generation of detailed plans in the early stages of the design process. This condition might demand great effort for revising the plans, considering that, according to Koskela (2000), there is much more uncertainty in design than in production.

Other initiatives have investigated the application of the Last Planner System of Production Control™, developed by Ballard and Howell (1997) in the design process. This application has presented some promising results when applied to the design process itself [Koskela *et al.* (1997), Miles (1998), Ballard (2000), Tzortzopoulos *et al.* (2001)], or to the integration of design and production planning and control (Codinhoto, 2003).

One of the main mechanisms to manage the PDP in situations of high uncertainty and interdependence is the reduction of information batch sizes (Reinertsen, 1997). However, according to Codinhoto (2003), the design process planning in construction using this mechanism represents a change in the conventional way designers are used to work, typically in large batches. In fact, Codinhoto (2003) concluded in his study that design professionals tend to resist to that change.

PRODUCTION PLANNING AND CONTROL

Considering the typical complexity of construction projects and the variability of their processes, it is often necessary to divide production planning and control in different hierarchic levels. In general, three hierarchic levels are suggested in the literature [Neale and Neale (1986); Laufer and Tucker (1987); Ballard (1997)]:

1. Long-term planning: it involves the definition of project objectives considering the client's profile. At this level some strategies to reach the project objectives are defined, such as project duration, financial sources and partnerships;
2. Medium-term or look-ahead planning: according to Ballard (1997) makes the link between the long-term and short-term planning. An important role of this planning level is to create conditions to continuous work flow, identifying and removing constrains to production (Tommelein, 1998).

3. Short-term planning: its main role is to guide production at the operational level. Ballard and Howell (1997) pointed out that setting quality assignments shields production units from work flow uncertainty, and is one of the main elements of Last Planner System of Production Control™.

RESEARCH METHOD

Two case studies were carried out in this research project. The first case study (CS1) had an exploratory character. Its main objectives were to identify the gaps in knowledge and to help defining the research questions and objectives. In the second case study (CS2) some mechanisms and tools for design planning and control were proposed, in which there was a reduction of information and design batch sizes.

An **information batch** can be defined as a chunk of information that do not correspond to a design document. A **design batch** can be defined as a design document, represented by drawing or text, and may include necessary definition for the development of another design batch, for the production on site, or for authority approvals.

The data sources adopted in CS1 were the production look-ahead plans and controls, short-term design plans, drawings and other documents generated during the design process, and interviews with the design team. Moreover one of the researchers participated in 12 design meetings in each case study, as participant observer. The decisions made during the design and production meetings were documented and the PPC (percentage of plans completed)[1] was collected. The sources of data adopted in CS2 were the same, and also a design batch map developed at the beginning of the study (see Figure 2).

Both case studies were carried out in a construction company (CC) which usually carries out fairly complex, uncertain and fast projects, such as hospitals, and industrial buildings, contracted by private clients. This company is based in Porto Alegre, south of Brazil. The CC has been involved in previous research projects concerning the conception and implementation of production management systems in partnership with the Building Innovation Research Unit (NORIE) of the Federal University of Rio Grande do Sul (UFRGS).

Some projects undertaken by CC involve only the production stage, and the design is provided by the owner. However, there has been a growing number of projects in which CC is hired for carrying out both construction and part of the product development process, which includes design coordination. This coordination is performed by either external or internal design managers. In such cases, design and production are usually developed simultaneously, which demands the integration of planning and control for both processes.

DESCRIPTION OF THE CASE STUDIES

CASE STUDY 1

Case study 1 (CS1) was carried out in a project that consisted of an extension of an existing industrial building complex. CC scope involved the construction of a building to support administration, dressing rooms, and refectory (1,023 m^2), a maintenance building (600 m^2) and the extension of the production

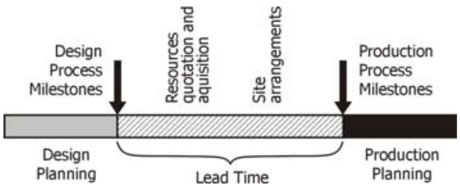
[1] This is a performance measure that is generated in the Last Planner System (Ballad and Howell, 1997)

line building (6,500 m^2). The duration of the project was 5.5 months, and the scope of the contract included both production and design coordination.

In CS1, as in most previous projects in which CC had been involved in design coordination, an initial design plan was produced according to the demands of production. In the production long term plan the starting dates of the main activities were established. Based on those dates, some design milestones were defined, taking into account the necessary time for procuring the resources and delivering them on site. This sequence is illustrated in Figure 1.

In CS1, the research team acted mostly as observers in design meetings. The only design planning tool that was introduced in this study was the design batch map, which was jointly proposed by one of the researchers and the project design manager. This map was produced from drawings and documents concerned with eight design disciplines. The purpose of the design batch map was to define the main large design batches to be developed by the design team, based on historical data, four months after the beginning of the contract. The main difference between this map and a conventional design plan is that this map indicates the most important interdependencies between design batches.

Figure 1. Procedure to design milestones definition considering the production planning.



Twelve interviews were carried out with members of the design team. The objective of those interviews was to identify the main interdependences were not showed in the map and the main problems that existed in the management of the design process, specially those associated with the design batch definition and with the design development sequence. Another topic that was discussed in the interviews was the set of main inputs and definitions necessary to develop each design batch presented in the map.

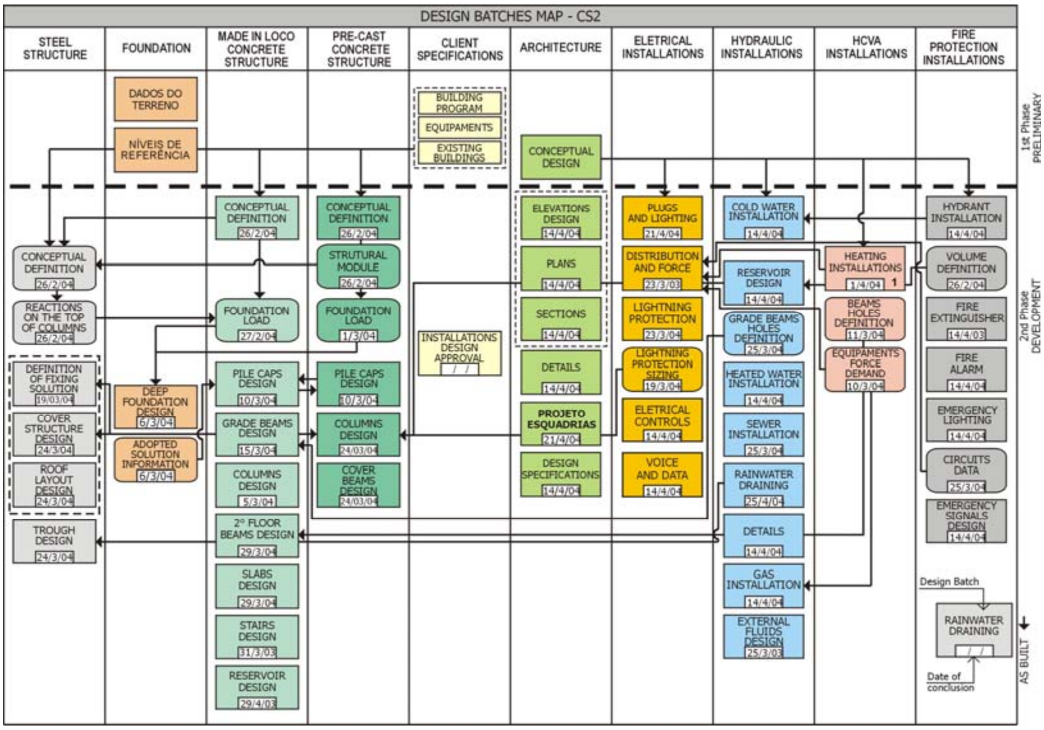
At the short-term planning level, the design process was programmed in weekly meetings involving the design team, considering the time horizon of 1 to 4 weeks. The activities were defined by breaking down large design batches established in the long-term design plan. Another source of design batches to be developed at the short-term level was the design constraints identified in the medium-term (look-ahead) production planning.

CASE STUDY 2

The second case study (CS2) was developed in a project that consisted of the construction of an industrial building (1,443 m^2). The contract between CC and the client included both the construction stage and design coordination. The total duration of the project was 4.5 months. Based on some of the problems detected in CS1 and also on the literature review, some changes in design planning and control were proposed.

A design batch map, as the one developed at the end of CS1, was devised and proposed as the final representation of the design long-term plan (Figure 2). The date for the delivery of each design batch was defined considering the need for the information reaching maturity before going to production. These dates were defined through procedure that was similar to the one represented in figure 1.

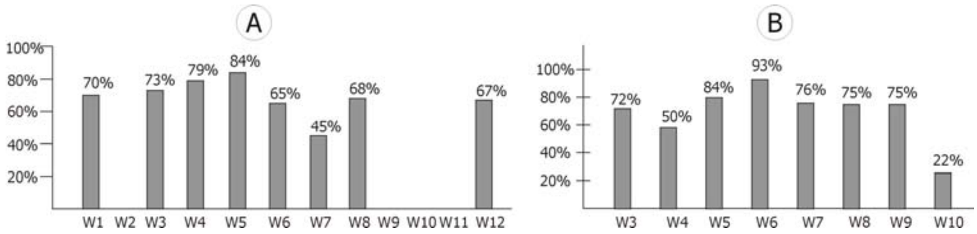
Figure 2. Design batch map of CS2.



Those design batches represented in the map were programmed to be developed by the design team in the short-term design planning. However, once the map presented large batches and their main interdependences, they had to be broken down into smaller ones due to existing interdependences that are not made explicit in that map.

Figure 3 compares the PPC (Percent Plan Complete) indicator that was monitored in CS1 and CS2. In CS1 there are some gaps in the indicators, mostly due to the time horizon of the plans (week 2, 9, 10 and 11). No monitoring of the causes for the non completion of work packages was made in CS1. In CS2 the PPC was tracked and the causes for non completion were identified. It was done by one of the researchers during the design meetings.

Figure 3. PPC for the design process in CS1 and CS2



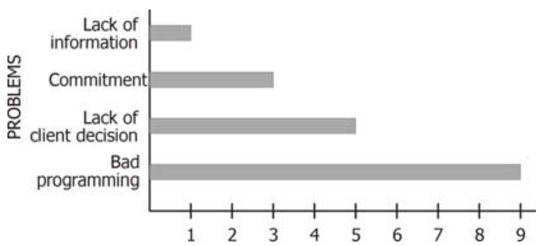
PPC design indicator presented an evolution between the first and second studies using the reduction design batches mechanism. Such mechanism had as main tool the design batch map, used in design planning in CS2,.

The PPC use helped the identification of effects of design batch map on design planning. Even with design PPC variability identified in the second study, there were no gaps between the planned weeks as presented in the first case study.

However, some difficulties were found for the PPC use on design process. The design meetings were guided by a project design manager. She was the person in charge for presenting the topics that should be discussed during the meetings, registering the decisions made and programming activities to be developed. This way, the difficulties to the PPC use in design planning were mainly due to the amount of activities that should be performed by the project design manager and the dynamic environment of design meetings, which counted with at least ten participants.

In CS2, through the PPC use and the identification of causes of non completion of work packages, it was possible to find the origin of faults on design activities programming. The causes for the non completion of design activities were classified in four main categories: bad programming, lack of client decision, problems with commitment and lack of information, as presented in Figure 4.

Figure 4. accumulated typology of design problems in design planning of CS2.



Activities not completed and classified as the result of bad programming were those with insufficient time to conclusion or misunderstood by the person responsible for its execution. Also, were classified as bad programming those activities not completed due to the overload on a responsible or, that depended on contractual uncertainties to be solved with the client.

Were classified as client lack of decision those activities not completed due to lack of design approvals or lack of information that should be provided by the client. The activities not completed due to lack of commitment were those programmed and not concluded by the design team for not being priority to their working or considered unnecessary by them.

Tasks that were not concluded due to problems of lack of information were related to definitions of other design discipline not received, interdependent tasks not concluded and programmed to the same period or, to misunderstanding among designers.

CRITERIA FOR REDUCING INFORMATION AND DESIGN BATCH SIZES

Based on the case studies, some criteria for reducing information and design batch sizes in design planning were proposed:

1. The initial definition of design batches to be developed, represented in the design batch map, should happen right away the phase of planning the planning process, the first phase of the model of planning and control process proposed by Laufer and Tucker (1987). This definition makes it possible the identification of main interdependences between different design disciplines, as well as the scope of the design team contract, increasing the transparency and contributing to reduction of uncertainty in the design process planning;
2. Some design disciplines tend to be more critical in a project. This criticality is mostly related to: the limited capacity to reduce design batch sizes, the difficulty for some professionals to increase the speed of design development, the lead time of some resources that are necessary for the production on site, and the large number of interdependences with others design disciplines. Such critical design disciplines must be identified at the beginning of design development at each new project, in order to consider alternatives that avoid harmful effects in the design and production processes;
3. Multidisciplinary meetings involving the design team have an important role in identifying interdependencies of smaller design batches and on helping to define the design detailed sequence for each project. In this way, the previous experience of design team has great importance;
4. The design batch map provided the initial definition of large design batches to be developed and the identification of main interdependences, increasing the transparency to design coordination. This tool enables the design coordination to do look-ahead planning and contributes to expedite discussions among the muldisciplinar team members in relation to information and definitions necessary to keep on design development. Also, the complexity of the final product and the interdependencies between design disciplines are determining factors in breaking down design batches at the short-term design planning level.
5. Once design and production processes are developed concurrently, the look-ahead production planning has an important role towards planning integration between those processes, since the design constrains identified in production planning can help defining design batches to be developed by the design team.

CONCLUSIONS

The case studies presented in this paper pointed out a gap in design planning and control. This gap is concerned with how to obtain the necessary reduction of design batch sizes in construction projects, once this mechanism is pointed out as proper to manage the PDP in situations of high uncertainty and interdependence. The proposed changes in the design process provided good results in terms of improving design planning and control, in complex, uncertain and fast construction projects, in which design and production need to be carried out simultaneously.

A design batch mapping tool was proposed, which supports the reduction of batch sizes. Its use as a planning tool supports the production of look-ahead plans for the design process, since the main interdependences among design batches of different disciplines are made explicit, as well as the conclusion dates according to production planning requirements.

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Exploratory Study on Construction Project Management in Southeast Mexico

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Abstract
There is evidence that small and medium size construction companies in Mexico dedicate great deal of effort to cost estimating, paying little attention to the planning aspects of their projects. Such practice leads to overruns in both time and cost. Lacking a thorough planning those firms are less likely to achieve comprehensive project control, so they could take timely decisions to keep projects on track. This paper presents the results from an exploratory study upon current project management practice by those firms. The study consisted on a survey to identify their problems, needs, and requirements. Findings show that only 78% of those companies plan their projects, and that only 61 % allocate staff for such task. Furthermore, most of them do their planning manually and empirically: 75% use improper management methods not taking advantage of current information technologies. The study also shows that those companies lack a comprehensive system to integrate and automate the great amount of information commonly generated during the project management process. Last, the authors propose an overall solution to this problem, consisting on a general scheme that systematically will lead those firms to select and use the proper tools to improve their project management practice.

Keywords
Project management, project planning, project control.

INTRODUCTION

There is evidence that small and medium size construction companies (PYMES) in Mexico dedicate great deal of effort to cost estimating, paying little attention to the planning aspects of their projects. Currently, it appears that while evaluating bidders, owners pay attention primarily to economic issues of bids and completion dates of projects, minimizing the importance of the planning function. Without detailed planning is less likely to achieve comprehensive project control, so builders could take timely decisions to keep projects on track. Such practice leads to overruns in both time and cost.

It is important to consider the structure and the organization of the construction industry in Mexico. According to CMIC (Cámara Mexicana de la Industria de la Construcción – Mexican Chamber for the Construction Industry) 93% of the firms are classified as either micro or small (CMIC, 2004), or

PYMES as defined in this paper. That is equivalent to the 90% of the so-called small firms in United States, firms ranging from the self-employed entrepreneurs to organizations housing 15-20 employees (Loría and Vanegas, 2005). Those are the firms dealing daily with the problems posed by planning and control practice.

Construction Project Management practice has been a major topic of interest at the School of Engineering of the Autonomous University of Yucatan (FI-UADY). Its Construction Graduate Program has undertaken a research program to help firms to improve their project management practice. As part of such program, an exploratory study was designed to identify problems, needs and requirements of PYMES regarding project management. The objective of the study was to gather information to know their current practice and, based on it, to propose a conceptual framework for a comprehensive system, or prototype, to help them in this respect. A sample of 23 companies from the Yucatecan Chapter of the Mexican Chamber for the Construction Industry (CMIC) was included in the study.

Other studies conducted at FI-UADY in the same topic have resulted in an "Automated Cost Control Comprehensive System for PYMES," by González and Domínguez (1998), and a "Materials Management System for Large Low Cost Housing Developments," by González and Tirado (1998). In this study, prior information from PYMES was updated to address more specifically key aspects of the planning and control management functions.

METHODOLOGY

This research effort focused mainly on "what" questions. Namely, what are the ways this company manages its projects? What are the tools this company uses to manage its projects? According to Yin (1994), these types of questions provide a justifiable rationale for conducting an exploratory study, since the goal is to develop pertinent hypotheses and propositions for further inquiry. Furthermore, meets all the conditions to select survey as the research strategy (Yin, 1994):

Table 1. Relevant Situations for the Survey Strategy

Strategy	Form of research question	Requires control over behavioral events?	Focuses on contemporary events
Survey	who, what, where, how many? how much?	No	Yes

Therefore, a structured personal questionnaire was designed to identify problems, needs and requirements of construction PYMES based in Yucatan, Mexico, regarding project management practice. This type of instrument allowed direct interaction with the interviewees facilitating clarification of doubts arising during the interview. In addition, it was possible to observe the interviewees' reactions while responding the questions, as a double check to validate their answers.

The unit of analysis was the construction companies based in Merida, Yucatan. Actually, at the time of the study, 291 construction companies were registered at CMIC. The sample size was calculated considering: a) population, b) degree of certainty required in the study, c) time constraints, and d) resources available for the research project. The procedure consisted of the following steps:

- Literature review regarding construction planning and control.
- Design of the questionnaire.
- Pilot testing of the questionnaire.
- Identification of errors and deficiencies, and adjustments to the questionnaire.
- Large scale application of the questionnaire.
- Analysis and interpretation of results.
- Conclusions.

The sample size was determined according to the guidelines provided by Cochran (1986), whom deems adequate the formulae posed below since: a) are the proper ones for exploratory studies, b) allow establishing the limits of error permissible based on the availability of resources, and c) allow adjustment for small samples. Therefore, the sample size was computed as follows:

$$n_o = t^2PQ / d^2$$

Where:

n_o = Sample size (Number of construction companies to interview)
t = Abscissa of the standard normal distribution function for the percentage of acceptable error (t = 1.645 for an acceptable error of 10%)
P = Population´s percentage in class C
Q = 100 – P (percentage)
d = Percentage of permissible error

The value of P was assumed: roughly 10% of the companies have and use (proper) tools to carry out planning and control functions for their projects. The value of d, 10%, was chosen considering two factors: 1) the magnitude of the study, e.g. exploratory, and 2) the resources available, primarily manpower, to conduct the research. The resulting number of firms, 24.4, had to be adjusted due to small sample conditions, as suggested by Cochran, with the following formula:

$$n = n_o / (1 + (n_o / N))$$

Where:

n = Final sample size
N = Population size

This resulted in a final sample size of 23 companies, selected randomly from the 291 registered at CMIC.

In order to obtain valuable data, the questionnaire of the survey was designed consulting literature related to project planning and control. A tree diagram was developed to help break down important information regarding all aspects of project execution. A preliminary draft of the questionnaire was elaborated containing 140 questions. The final version of the questionnaire consisted of 65 questions selected from those that could help to obtain valuable information for the study. The 65 questions cover four major areas: 1) General Data -4 questions, 2) Construction Planning -31, 3) Construction Control -28, and 4) Willingness to collaborate in the development of a proposal -2 questions.

A test pilot was conducted to calibrate the questionnaire; four professors at FI-UADY, selected among those that had managerial experience in the construction industry, and a senior manager from a construction company were included in the pilot.

Upon arrival at the firm, the interviewer requested the collaboration of someone knowledgeable to respond the questionnaire. A copy of this instrument was handed out to the interviewees in order to expedite the process and avoiding tiring them. Most participants were either owners or general managers from those firms, all of them kind and cooperative. Interviewing required 4 weeks.

The analysis of the answers is summarized in Figure 1, portraying actual planning and control practice. A conceptual scheme was derived from it, shown in Figure 2, aimed to provide a comprehensive solution to the problems found.

RESULTS

General Data

The average age of the companies is 10.4 years. The types of construction they are involved is distributed as follows: building 40.5%, housing 26.2%, facilities 14.3%, roads 9.5%, and "other" 9.5%.

Regarding their size, according to CMIC's criteria, based on annual production volume, the companies were distributed as shown in Table 2.

Table 2. Classification of PYMES

Year	Micro	Small	Medium
1997	36.8%	21.1%	42.1%
1998	42.1%	36.8%	21.1%
1999	52.6%	21.1%	26.3%

The survey also revealed the way companies obtain their contracts: 63.8% primarily through negotiations (ranging from 20% up to 100% of their total contracting); other 39.9% through public competitive bidding (5-80%); 31.0% through private competitive bidding (10-60%); and 21.7% through the build-operate-transfer option (10-35%). The prevailing contract types are *unit price*, 82.4%, and *lump sum* 33.6%.

Construction Planning

It was found that 78.3% of the PYMES undertake some formal construction planning and the 21.7% remaining do not. From those PYMES that plan, 61.1% has a planning team primarily integrated by civil engineers; the remaining 38.9% do not have specific staff allocated to that function. It was also found that scheduling is primarily done through Gantt charts, 75% of the firms, and that only 25% schedule their projects using network diagram methods (CPM or PDM).

This section of the questionnaire was designed for a twofold purpose: 1) gather information about current project management practice, and 2) identify willingness from interviewees to adopt a new system model that could help them to develop a more comprehensive planning phase.

Construction Control

All interviewees mentioned they control the construction phase of their projects. However, do not have means to evaluate the quality of results. Near half the PYMES, 47.8%, have a specific control team, integrated primarily by civil engineers; the remaining 52.2% do not have specific staff allocated to this function, project managers, field engineers, or foremen, are responsible for controlling time, cost, and quality of the construction project under their responsibility.

Regarding the level of satisfaction that companies have about their current control systems, interviewees answered the following: very high 13.0%, high 30.4%, 43.5% good, not sufficient 8.70%, and bad 4.4%. Their answers allowed to infer that those control systems are mostly empirical and mainly based on experience only, not on strong data generated from comprehensive planning and control practices. It was also inferred that control is primarily focused on getting to know the final performance results of their projects, as useful information for future projects but not for taking timely decisions during the execution of the projects.

Several computer programs are used for controlling projects in 74.0% of the companies, the remaining 26.0% does it manually. Among PYMES with an automated control tool, SINCO (Sistema Integral de Costos -Integrated Cost System), a program developed by faculty at FI-UADY, is the software most used. However, it only includes a few simple automated control tools. SINCO is primarily aimed to help contractors to cost estimate and budget their projects, and to document progress payments as well not for control purposes. Most interviewees using SINCO said they have a good knowledge and experience handling it.

PYMES carrying out control manually are focused on the following aspects: project's delivery time, allocation and consumption of materials, cost comparison (actual *vs*. planned), labor, equipment, and supervision costs. Most of them, 83%, do not consider necessary automated control, while 17% mentioned that do not have qualified personnel to use computers for projects' control.

This section of the questionnaire was also designed to gather information to develop a new system model that could help them to establish a more comprehensive control phase.

Collaboration to Develop a Control System

It is worth mention that 87% of the interviewees indicated that they are willing to collaborate in a research project focused on the improvement of construction control practice. Sixty four percent of them mentioned they could provide their own experiences, 28% were interested in testing any automated control system derived from the project, and 8% expressed that could provide financial support.

Results Analysis

Results show that most construction companies are concerned with planning and controlling their construction projects. However, they carry out those tasks in an overly simplified way, as shown in Figure 1; and not as suggested by theory described on the literature review, summarized in Figure 2.

Figure 1. Current local practice on execution of construction projects

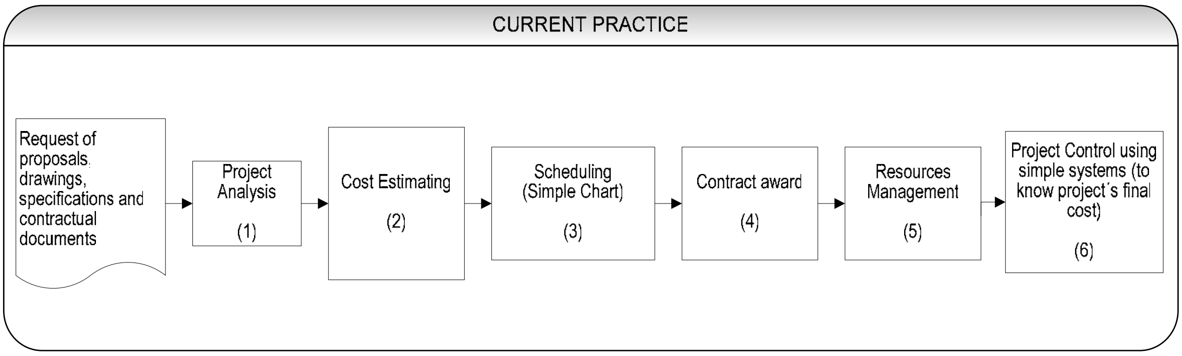
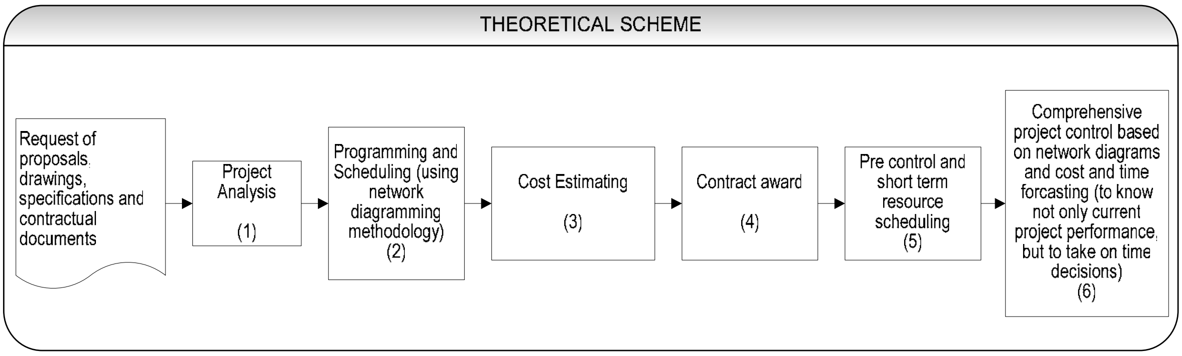


Figure 2. Project planning and control, theoretical scheme



DISCUSSION

The local market share of PYMES is rising. The authors believe that it is a good idea for the Construction Program at FI-UADY to undertake a research project aimed to help those companies to be more competitive; Project Management must be one of the important areas of such project.

Even though construction planning in local companies is actually done, it is plagued with errors. It is mainly based on experiences from past projects, and only occasionally is made with rigorous analysis of information. This is probably because their first priority is cost estimating, since owners pay attention primarily to the financial aspects of bids. Therefore, contractors dedicate a great deal of effort to cost related matters. Once they get a contract, the time they have prior to start construction is very short; and again, they do not focus in the planning aspects of projects because they have no time for it. It could be easily inferred then that, PYMES are not able to do planning comprehensively. The authors wonder if this situation is similar to other parts in Mexico or to other countries in Latin America. If that is the case, it will be worthwhile to share findings from this research.

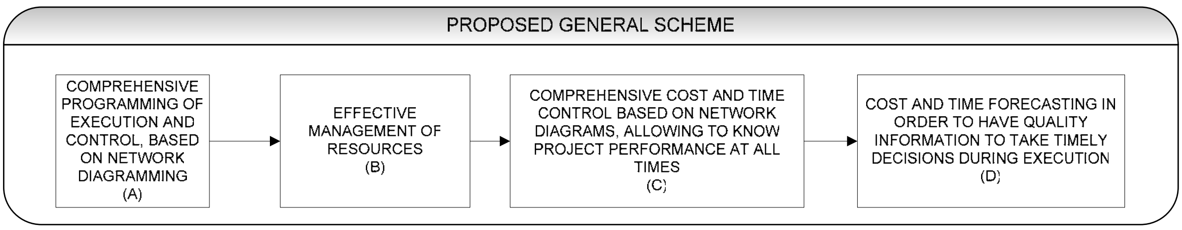
Theory upon Management recognizes that planning is the function that supports the other ones. Therefore, it will never be a waste of time to try to improve it, looking to increase the probabilities of success for a project. Olusegun *et al.* (1998) already recognized that "there is a need to examine actual planning practices and develop strategies to improve planning efficiency in the construction business."

Regarding control, interviewees also mentioned they carry out construction control. However, the authors concluded that it is mainly focused in knowing past performance of projects; they cannot make use of it to take timely decisions. We assume they only have a vague idea of the potential use of construction resources' control. Hence, a key question is: How could they implement comprehensive control if they do not rely on comprehensive planning?

CONCLUSIONS

It is urgent to help PYMES to do a more comprehensive planning and control of their construction projects. To reach this goal it is necessary to introduce some processes for those companies that have been awarded with contracts. The overall processes is shown in Figure 3. The authors propose to substitute steps 5 and 6 on Figure 1 for steps A to D on Figure 3.

Figure 3. General proposal for improvement in the execution of construction projects.



Companies will have to carry out these processes in an expedite way for every project, otherwise they would not achieve comprehensive project programs and required information to take timely decisions. Moreover, it can also be inferred that companies lack a comprehensive system to integrate and automate the great amount of information that is usually generated during the project management process. The authors assume that PYMES cannot afford to develop systems suited for their own specific needs because of cost reasons primarily. Therefore, it seems a good idea to develop a prototype to integrate planning and control in a system that could automate the management of information. The system should be developed in such a way that every company could easily adapt it to its own needs.

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Delivery Process: A Model to Overcome the Challenges of High Performance Green Projects in Developing Countries

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Abstract

Owners in developing countries are becoming increasingly aware of the environmental and economic benefits of high performance green (HPG) buildings. HPG buildings are typically characterized by their ability to optimize indoor environmental quality, energy conservation, and performance over the life of the building while not adversely affecting the environment. These attributes can enable HPG buildings to provide shelter to developing countries appropriate to the environmental conditions and to lower operating expenses over the life of the facility. Attempts to efficiently manage HPG projects are challenged by the added complexity and ambiguity associated with HPG building requirements. In developing countries these challenges are exacerbated by the limited availability of advanced construction technologies and methods and an insufficiently skilled labor force. Existing research has shown that inefficiencies in the management process are best addressed in the early phases of construction since the savings potential of the project drastically decreases with project progress. This paper aims to demystify the HPG building process by identifying practices that if implemented in the pre-design phase contribute to the successful delivery of these buildings. Understanding the unique characteristics of the AEC industry and the local design vernacular in developing countries were found to be fundamental to success.

Keywords

Project management, high performance green

INTRODUCTION

"Much ingenuity with a little money is vastly more profitable and amusing than much money without ingenuity." *- Arnold Bennett*

The Architecture/Engineering/Construction (AEC) industry in developing countries compared to industrialized countries is distinctly affected by several factors. These include an insufficiently skilled labor force, the limited availability of advanced technologies and methods, and materials, and

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the low priority of the environment. These factors reshape in a developing country what might be regarded as an effective construction solution in an industrialized country. For example, the use of prefabrication can be technically impractical and often not needed. Yet in industrialized countries this is an urgent development to solve labor shortages in this industry. The construction of a high performance green (HPG) building in developing countries with its added complexities requires additional ingenuity to address the challenges and to promote more sustainable solutions.

For the purpose of this paper the delivery process of a construction project is defined by its phases: plan, manage, design, construct, operate and maintain. The focus of sustainability in the AEC industry in industrialized countries has been the design and construction phases. However, there are still numerous uncertainties in determining how to manage such projects. This often leads to process waste (such as lower productivity) and eventually to higher building costs. The reduction of these higher process costs is often left to the ingenuity of the project owner and construction manager. In industrialized countries, these ambiguities are frequently countered by the application of advanced technology to systems, materials and methods to bridge the gap between conventional buildings and HPG building requirements. This approach is not always transferable to the construction of HPG buildings in developing countries due to the vast differences in the AEC industry in such countries. Addressing the challenges to the management and construction process in the earliest phases of the delivery process can reduce the cost, eliminate process waste, and secure overall project success, and is a method that may be used in both industrialized and developing countries. Paulson (1976) showed that, decisions have a much greater influence in the earlier stages of the delivery process. Research has also shown that when just one percent of a project's upfront costs are spent, up to 70% of the life-cycle costs of the project may already be committed [Paulson, 1976].

This research will focus mainly on the challenges encountered by the project manager in the delivery process of a HPG building in developing countries and to provide model guidelines to reduce uncertainty. Based on the fact that "as time passes during a project, opportunities to reduce cost decrease while the cost to implement new ideas increases," it is prudent to invest in pre-design [Avant and Ogden, 2005]. Pre-design includes the activities that take place before the schematic design is developed, and activities such as team selection and planning. The schematic design is then used to award subcontractor contracts. At this stage in the process it is more difficult and costly to implement HPG features. The added complexities attributable to HPG building requirements will need to be addressed early in the delivery process to optimize the cost and energy saving potential available early in the process. Strategies to overcome challenges and optimize the savings potential of pre-design include clearly defining HPG goals and commissioning plan scope, understanding the specific characteristics and needs of projects in developing countries, selecting and equipping the appropriate project team, and developing knowledge management tools.

RESEARCH METHODOLOGY

The goal of this research is to identify challenges in construction in developing countries and compile guidelines for overcoming those challenges. First, it was necessary to define HPG; identify the benefits of HPG buildings; and then identify the challenges faced in the construction industries in developing countries. For this effort, literature review formed the most appropriate strategy. The challenges identified during the literature review were compiled from sources located in several different countries. Literature review was a relatively inexpensive way to collect diverse data about construction practices in several developing countries. With this information, and the expertise of an experienced property development manager, model guidelines were developed to help engage these challenges.

HIGH PERFORMANCE GREEN BUILDING

Definition

The industry accepted and more condensed definition for a high performance green buildings are those that are typically characterized by their ability to optimize indoor environmental quality, energy conservation, and performance over the life of the building while minimizing adverse environmental effects [SBIC, 2004].

Benefits of HPG Buildings

On a global scale the AEC industry is responsible for up to 40% of the world's resource consumption and produces about 40% of the waste including green house gas emissions [Prasad and Hall, 2003]. Much work has been done to address these and other poor building performance issues. These exciting advancements include understanding the design and construction of high performance green (HPG) materials and building systems. The accomplishments achieved by HPG buildings include a reduction in adverse effects that buildings have on the environment, energy consumption and occupant health. A publication by the Sustainable Buildings Industry Council (SBIC) stated that in the U.S. high performance green buildings were reported to use 30% to 50% less energy than conventional buildings [SBIC, 2005]. High performance green buildings have also increase occupant productivity by an estimated 7% and reduced absenteeism by approximately 15% [Washington Environmental Council, 2005]. In many cases these successes were in some way the result of time invested early in the delivery process.

On the Cheyenne American Indian reservation, a region best described as developing in the U.S., most of the money earned is spent on energy needed for heat during extreme winters and for cooling during scorching summers (AIHI 2005). The benefits of HPG buildings if applied in developing countries may reduce the amount of money spent on operating and maintaining buildings, especially in environments similar to that on the Cheyenne Indian reservation.

CHALLENGES OF CONSTRUCTION IN DEVELOPING COUNTRIES

Despite the significant capabilities of HPG buildings to meet the needs of the AEC industry in developing countries, there are many challenges that impede the adoption of HPG building solutions in these countries.

Insufficiently Skilled Labor

The construction labor force in industrialized countries is more consistent that in developing countries since the availability is primarily dependent on the number of projects being done and the industry is not typically concerned that significant portions of the labor force will be diverted seasonally by other industries. However, in many developing countries the construction laborers are characterized as being under skilled and have low productivity. Most construction projects in these countries utilize "unskilled agricultural labor" for the construction, operation and maintenance of the building [Jaselskis and Talukhaba, 1998]. This creates an AEC industry that is dependent on the inconsistent demands of the agricultural industry.

Limited Availability of Advanced Technologies and Methods

In industrialized countries, advanced materials and technologies such as on-site material and equipment hoists and prefabricated building components are used to reduce the cost of labor and to cut the schedule time. The opposite is usually true in developing countries. Many developing countries sustain labor-intensive construction practices. Also the use of time saving technologies are overlooked in most developing countries because of the cost of labor is much lower than the cost of advanced technologies. The cost of labor trails that of industrialized countries by a factor of between 2:1 and 50:1 [Thomas, 2002]. This large disparity in cost of labor perpetuates labor intensive construction methods resulting in a very labor-intensive construction process which affects the productivity, quality and schedule of construction projects [Jaselskis and Talukhaba, 1998].

On construction sites in developing countries it is typical that materials and equipments are prepared and transported manually. For example, in Guatemala and Cambodia concrete is mixed onsite manually in small batches even for large construction projects. In cases where more advanced technologies are available such as fork lifts and cranes, inadequate training, availability and cost of the machinery and its replacement parts restrict the use of these technologies. Also lacking in developing countries is an infrastructure capable of supporting the production of construction equipment and prefabricated building components. Thus the bending and assembly of rebar cages is carried out by the laborers.

Limited Availability of Advanced Materials

As previously mentioned materials such as concrete are prepared on-site. Ready mix it not typically available or affordable in developing countries. Similar to advanced technologies, the infrastructure in these countries is not capable of supporting the demands for construction materials. The indoor environmental quality and 'green' characteristics of a HPG building is greatly affected by the materials selected for use throughout the building. In many developing countries basic construction materials are sometimes not readily available or locally sustainable. For example, in Kenya, there are two cement plants. The capacities of these plants are unable to support the needs of the entire country [Jaselskis and Talukhaba, 1998].

Lower Priority of the Environment

In 1985, it was reported that an estimated 40% of the population in developing countries lives in absolute poverty [Jaselskis and Talukhaba, 1998]. There has been little improvement since then in many of these countries. Also the rapidly growing populations of developing countries increase the stress on natural resources by trying to meet the population's basic needs. Therefore the desire to protect the environment is given a lower priority to the more immediate social and economic demands.

BACK TO THE BASICS

The potential success of a project is most positively influenced in the pre-design stage of the delivery process. Different approaches to the delivery process are required in industrialized and in developing countries, in that, for projects in developing countries information is required on the local characteristics and specific needs. Figure 1 below shows the information gathered in a typical pre-design phase in an industrialized country. The figure also shows the additional information required to enable successful delivery of HPG projects in developing countries: understanding the local business culture, local climate (biome), the local vernacular architecture, and the availability of local sustainable materials and the condition of the local labor force. Taking a few steps back to the basics by gathering this additional information is required to create a project which is responsive to the local challenges.

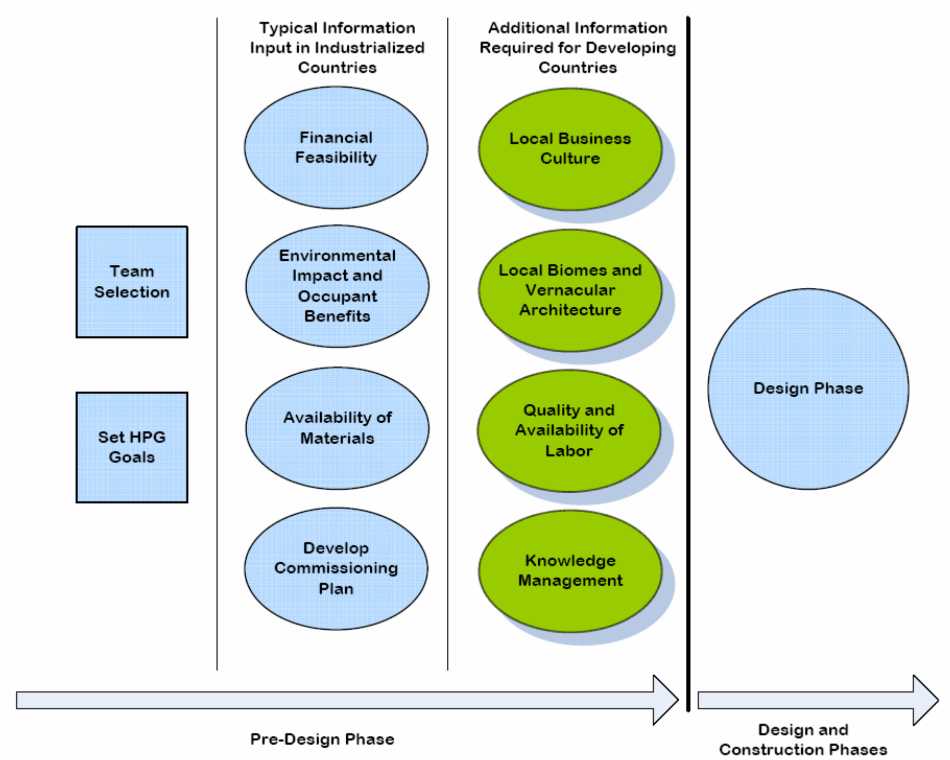

Figure 1: Additional Information Required During Pre-Design Phase

Selecting and Equipping Appropriate Teams

The project leadership team (design and construction management teams) forms the backbone of the delivery process for any construction project. This is important in HPG buildings since their performance characteristics demand the integration of systems thus requiring the integration of a multidisciplinary project team. In selecting the project team it is important that these members have experience in delivery in developing countries and are willing and committed to pursue HPG. It is also important that these team members are knowledgeable and experienced in HPG building design and construction. Laborers and supervisors should be trained on the importance of the high performance green characteristics of the building. Knowledge of the benefits ‘green’ thus influencing the team to be more committed to achieving the HPG goals set for the building. Training received in the early in the delivery process later reduces the occurrence of poor uneducated decisions made on site.

Define HPG Goals and Commissioning Plan

It is important to set environmental and energy performance goals for the building in the pre-design phase. Setting goals creates standards by which the performance of the building can be measured [DDC, 1999].

Building commissioning ensures that the building performance goals were achieved and that the high-performing and green building components were provided and installed as specified. A journal article published in the Heating/Piping/Air Conditioning (HPAC) Engineering, commissioning is defined as a “systematic process of ensuring that all building systems (mechanical and non mechanical) perform interactively according to the design intent, that facility staff are properly trained, and that documentation has been adequately provided” [Stum, 2000].

One of the benefits of commissioning is that potential building performance issues are caught up front reducing the life cycle cost of the building. It is important to create a commissioning plan during pre-design. This plan should identify and describe the commissioning activities before and after construction completion [DDC, 1999].

Understanding Local Business Culture

The integration of teams and systems is important for the success of a high performance green building project. Knowing and understanding the business culture in a developing country could make or break the success of a construction project.

The business culture in developing cultures is greatly influenced by the economic and political stability of the region. The construction industry in industrialized countries is greatly regulated by the government and its policies; however, the government’s influence is even greater in developing countries [Jaselskis and Talukhaba, 1998]. In less stable countries there is a higher level of risk that will need to be assumed by the contractors. Knowledge and in some cases the implementation of the local management styles have positively affected the resulting construction project.

Understanding the Requirements of the Local Biome

Biomes are major geographic regions characterized by their *dominant forms of plant life* and the *prevailing climate* [Dictionary.com]. The world is separated into five major groups of biomes, four of which are terrestrial: aquatic, desert, forest, grassland, and tundra. Each biome has specific requirements in the design and construction of buildings to support livable environments. It is important for imported teams (management or contractors) to become familiar with the building performance requirements of a specific biome. It is only then the goals of a high performance green project can be specified. It is also important to study the local vernacular architecture. There is much to be learned from the design and construction materials and techniques that have evolved locally.

Gaining an awareness of the environmental issues being faced by the region or country of the construction project is critical. This is especially important in HPG projects since one of the characteristics of a HPG building is that the adverse environmental effects of its construction and operation should be minimized. For example, Tanzania like many other developing countries suffers from deforestation. It would not be prudent to attempt to design and construct log cabin type housing schemes throughout the country. “Developing countries have the opportunity to avoid making the developed world's past mistakes of constructing buildings without considering the long-term implications on natural resources” [Parsad and Hall, 2003].

Study Availability of Resources

The availability of materials, equipment and skilled labor is specific to every region. These regional characteristics are greatly influence the outcome of the project delivery process. Materials, equipments, and the same level of skilled labor may not be present in developing as is in industrialized countries. “New technologies clearly have a role to play in providing environmental benefits. These need not be complex, and in terms of availability, affordability and acceptability, must be appropriate for the particular area and use available resources” [Parsad and Hall, 2003]. An appropriate technology is characterized by the following:

1. “It must be conceptually and physically compatible with the abilities of those responsible for operation and repair.
2. Spare parts and equipment must be available for maintenance and repair, which unfortunately often presents a problem with wind and solar technologies. Imported parts are often a challenge to find, or too expensive to purchase. Projects depending on local resources support the local economy and make parts replacement more feasible.
3. Financing the project must be within the means of those bearing the cost. If small, local organizations are financially responsible, user fees are often a good way to ensure steady income for maintenance and repair.
4. The technology must be compatible with the physical environment where it is used…” [Parsons, 1996].

Develop Knowledge Management Initiatives

The AEC industry as like any other is dynamic in its work teams. However, construction organizations in industrialized are able to retain and pass on knowledge and experiences through databases, training and mentor programs. These organizations are also usually able to support a core group of personnel with varying expertise. The benefits of having the knowledge and experience of past projects available for the use on current projects will aid in better decision making and the cost savings of avoiding errors made previously. The development of knowledge management initiatives for AEC organizations in developing countries will have the same benefits.

CONCLUSIONS & FURTHER RESEARCH: TEAMS AND TOOLS TO OVERCOME CHALLENGES

The lack of specific design goals, decentralized management of the green building process, and insufficient time and funding are some of the main challenges faced by project managers of HPG projects. The additional challenges experienced by the HPG project in developing countries heighten the importance of the pre-design phase in the delivery process.

Overcoming these challenges can be achieved with a process model that is centered in the pre-design phase of the project. Such a model was presented in this paper. This model begins with the selection of a project team comprised of professionals who are either sensitized to these challenges or at least receptive to learning about the benefits of early goal-setting, research, knowledge management, optimization of systems and commissioning. Additional time invested in the pre-design phase to understand the specific local characteristics and needs of projects in developing countries creates a heightened awareness of opportunities to counter the challenges faced in those countries. Once these opportunities are identified and seized, they can be researched, understood and overcome using locally sustainable solutions.

Project teams in developing countries often do not have the luxury of applying advanced technology to overcome their local challenges. Often the initial high costs associated with these technologies, despite the significant related operating savings, makes them unfeasible and impractical for many developing countries. In these circumstances, it is imperative that the team take necessary step back to the basics and perform the additional research necessary to create a project which is responsive to the local challenges. This is why research on the process of HPG building projects is critical to unlocking more of the benefits of HPG for developing countries.

Further research is needed to validate the proposed model and to understand its ability to impact building development in developing countries.

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Information System for Work Management on Construction Site - PLANTRACKER

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Abstract
The work development in the construction sector is marked as extremely fragmented. It is usual the existence of different agents working in separate environments with little coordination and communication. The absence of cooperation between these agents provokes losses of efficiency and productivity in the activities of the sector. The information technology has enhanced the capacity of communication between the participants of a project. However, the Internet paradigm requires information systems more efficient, that can better taken advantage of the world connectivity for the information flow management and a bigger interaction between the partners of the business and the knowledge. This paper introduces a computer program developed under SIGEO research project in Brazil. The system named PLANTRACKER consists of a WEB portal, with the collecting and synchronization of data through mobile devices working in the construction site. The main contribution of the research project is the integration proposal in the web environment of the information generated from work development to the time planning, quality and safety control. This proposal aim at to bigger precision in the information transferred for the planning and control system. The paper also presents the results of initial case studies carried out with the system in the city of Curitiba.

Keywords
Planning and control, work management, quality management, WEB systems, mobile computing.

INTRODUCTION

This paper introduces a computer program developed under SIGEO research project, conducted at the Research Group on Information and Communication Technology (GRUPOTIC www.cesec.ufpr.br/grupotic) of the Federal University of Paraná and funded by the FINEP national agency (CT-INFO/FINEP-2002). The project had two main objectives: development of computer software for construction planning and control using information straight from the construction site and create a spin-off company at the Federal University of Paraná to introduce the product in the market. Both the objectives had been reached with the development of PLANTRACKER system and creation of the TechResult Company.

The work development in the construction sector is marked as extremely fragmented. It is usual to exist many different agents working in separate environments with little coordination and communication [Nitithamyong and Skibniewski, 2004]. According to Dawood et al. (2002) the lack of cooperation among these agents provokes losses of efficiency and productivity in the activities of the sector. The Information and Communication Technology (ICT) appears as an important tool to reduce the problems caused by the construction industry fragmentation.

Paradoxically, nowadays this is still one of most delayed industry in use of ICT. [Lima, 2005]. According to Nascimento and Santos (2002) and Nitithamyong and Skibniewski (2004), this is caused by a set of barriers related to professional behavior, aged process, some construction sector characteristics and technological deficiencies.

The integration of the construction process with information can now be reached through ICT, especially with Internet technology. [Dawood et al., 2002]. Nowadays it is common the integration between many planning and control systems, as well as between ERP systems [Soibelman and Caldas, 2000]. However, for many companies these advances have been concentrated in office processes and cannot be extended to the construction sites, mainly because of the lack of communication technologies and the lack of low cost systems [Soibelman and Caldas, 2000].

In this way, the main contribution of this research project is the integration proposal of the information generated in the construction site with planning and control in a web environment, using also mobile devices. The information system focuses on project planning, scheduling, quality control and safety.

Among all ICT technologies the Internet is the one that best facilitates a collaborative working environment in a construction project [Nitithamyong e Skibniewski, 2004]. The project management websites, also named extranets or web-based project management systems, are in present time one of the main information technology application for construction [Santos and Nascimento, 2002]. Soibelman and Caldas (2000) define extranets as a net of computers which uses the Internet to connect companies, suppliers, costumers and other companies with the same aim. The project extranets have made possible a significant growth in the communication capacity among project’s stakeholders. Most of the studies about commercial extranets focus the collaboration between designers over the conceptual phase of the project. However, according to Isatto e Formoso (2004), considering extranets just as collaboration systems for design can limit significantly the potential benefits of this type of system.

Another important characteristic of this research project is the proposal of incorporate Last Planner concepts to the system developed. The Last Planner System as defined by Ballard (1994) has the aim to assist in short and medium term planning adopting lean construction principles. Many researches around the world were conducted to improve Last Planner System efficiency with computational tools as pointed by Villas Bôas e Mendes Jr. (2005). Villas Bôas conducted a master dissertation research project which resulted in an object oriented computational model for Last Planner System practical contribution of some companies which make use of this system. Such research was developed in parallel to the development of this project and major of its ideas were incorporate to the planning and control system module.

According to Chin et al (2004) the ICT advances could improve documentation and communication in quality systems process through various technologies such as the Internet, databases and web-based collaboration tools. However, the authors affirm that there has been a lack of research on how the quality systems process can be supported by the computerized and collaborative environment for better productivity of quality management in the construction industry. PLANTRACKER has many requirements focusing on the process for quality management and collaboration among project participants during the construction phase, such as inspections, nonconformance reporting and status of the inspection process.

PLANTRACKER permits in its control module the use of mobile devices technology, which has been growing in construction computer applications. [Aziz et al, 2004]. This research project intends to go beyond the limitations indicated by these authors, mainly related to remote collaboration (aspect more wide than a simple delivery of information), the easiness of connected use and the full data synchronization, in order to increase the use of mobile communication in construction site.

RESEARCH METHOD

The research was done on three phases: 1) A concept test to study and show the use of the web technology associated with mobile devices in the construction management; the final product of this phase was a prototype named Galápagos (Mendes Jr. et al, 2004). This prototype restrained barely to basic task planning and execution control. 2) University-companies workshops to create specifications for new functionalities aiming at the development of the final prototype; they were developed with professionals of two construction companies of the region of Curitiba, professors of the UFPR, UFF and UEPG and the project team. These studies were carried out through workshop meetings, and visits on the companies' offices and construction sites. In these visits were carried out structured interviews with the responsibles by the diverse levels of the organizations, from directors to the technicians, with the purpose of collect information, known the approach of work, and the main difficulties found on business processes, in order to discuss new requisites for the information system. 3) Finally, after the conclusion of these studies, it initiated the development of the PLANTRACKER prototype, obeying to the requirements established, including a sub-phase for testing and deploying the system.

PLANTRACKER SYSTEM DESCRIPTION

Features

PLANTRACKER was developed aiming at provide planning and control in the operational level, using information collected straightly in the construction site through mobile devices (PocketPC). During the execution of the previous workshops it were incorporated functionalities of work safety work control and quality of execution verifications with the purpose of attending the difficulties related by the participants of the workshops in manage those information in the construction sites with conventional information systems. As concluded in the workshops, the implementation of quality control and safety management requires a great quantity of papers for register information - being so on unnecessary since the data are persisted in databases.

Another important point discussed on the workshops discusses the need of adaptation of the system to the peculiar managerial and operational realities of the construction companies. Neither all of the users should have complete access to the functionalities available, seen that they will perform peculiar actions in the software. The solution used in many corporate systems was the adoption of dynamic profiles with also dynamic permissions, configured by a system administrator.

Also it was pointed in the workshops the need of functionalities for recuperation of task information and work developed in previous construction phases, as well as for creation of processes patterns. This need motivated the modeling of a conceptual detachment between the information concerning the companies and the information of its respective projects using layers. In the company information layer are gathered all the information of works and labor standards for use in its entire works. In the project information layer are gathered specific information of the projects, as quantities, time planning, execution measurement data, reports of not-conformities, resource allocations, and so on.

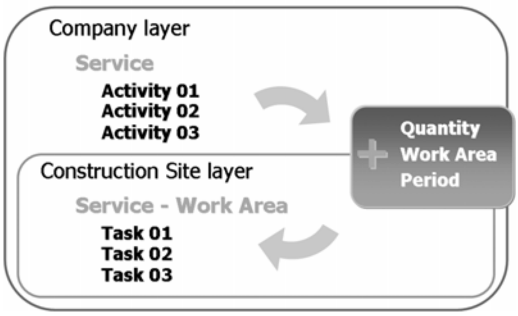
Application Modeling

The conceptual activity modeling was based on Souza and Amorin (2001) research which presents the data structured in two lines:

- A space logic, in which each work is associated to a work area
- Services and activities logic, based on the concept that tasks are a set of activities necessaries to accomplishment of the project.

In PLANTRACKER system two entities were defined, named services and activities, that are related to company's conceptual layer. These two entities contain data that are common to all company's projects, allowing standardization of the company's work. Services and activities are entities with the same characteristics, only differing in the sense that services are more wide-ranging (as the construction of a beam) and activities are more specific (as the formwork for concrete beams). Another important point for understand this concept is that an activity always belongs to a service. The services and activities data added to special logic information (quantity, work area and period) are incorporated to construction site layer named service-work area and task, respectively. (Fig. 1)

Fig. 1 Information model



PLANTRACKER was conceived for operate in two operational bases interconnected:

• *Web:* corporate extranet being able to be accessed by any computer with access to Internet through any web navigator. This operational base is sufficient for attend alone all of the requirements of the system PLANTRACKER
• *PocketPC:* application for mobile devices having as base the operational system Pocket PC ™ 2003 from Microsoft. This base permits the utilization of the system facilities for task, quality and safety control working in the construction sites.

The development technology adopted in the two bases was the Microsoft .NET technology (created by Microsoft in 2002) that simplifies the development of web applications and also mobile devices applications, as well as the communication between them through web services.

The Web Application

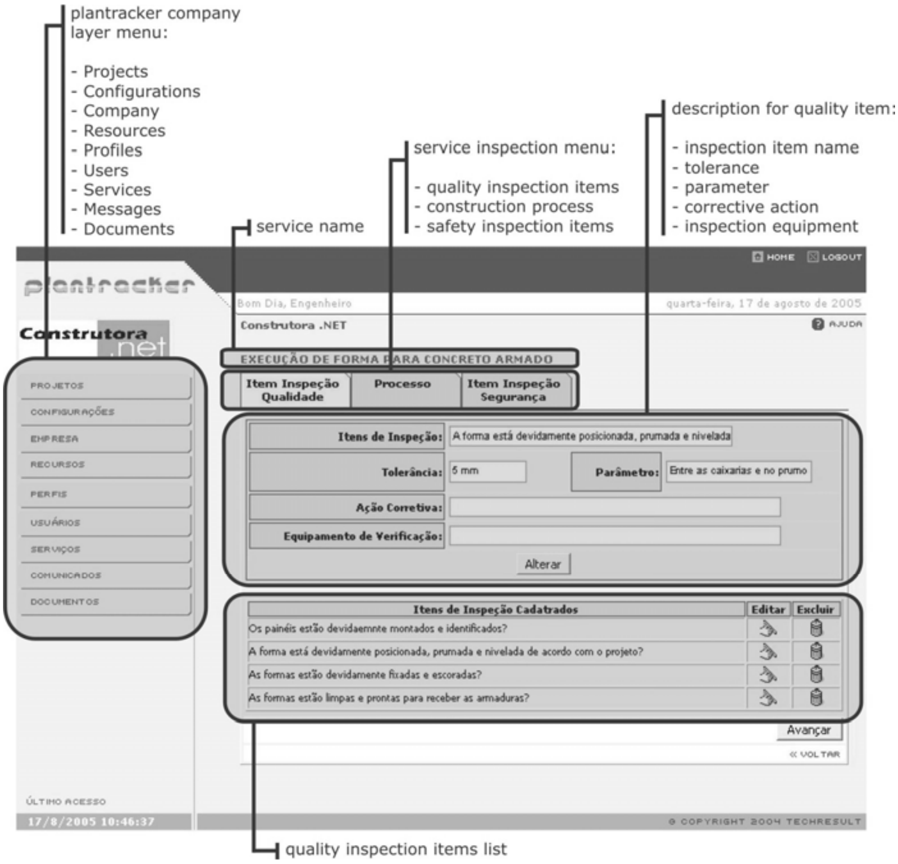
PLANTRACKER integrates information for planning, control and quality management, and construction site safety information. The user interface is separated in two layers: Company and Construction Site, as data modeling too.

Company layer presents features to create new projects, configure the company information, add sub-contracted companies, add users and define their respective profiles. PLANTRACKER has also some collaborative features like Document Management, Project Directory and Send and Register Messages. However, the main company layer feature is to define the company's services and activities structure.

Inside the services and activities structure is gathered the information of process execution, quality and safety control (Fig. 2). This information is standardized to all projects and composes the construction company plan. The quality and safety control information is gathered through check items for inspection that must be verified on construction site using the mobile device application.

Inside construction site layer are the features to indicate which users have access to a specific project and their respective profile in this layer, store general project information, task planning and control, quality and safety management. After registering the construction site information, it is possible to visualize reports on measurement, productivity, construction problems, nonconformance, and quality and safety control.

Fig. 2 PLANTRACKER application screen



Mobile Device Application

The functionalities of execution control, quality and work safety in the project information layer can be operated optionally in the mobile devices module (PocketPC base) (Fig. 3). Because of ergonomic features the resources of mobile devices interface are limited, mainly in the data input. Thus the functionalities available on mobile devices restrain itself to the operations for control.

These control functionalities provide to the user the closest information of which service-work areas and tasks should be performed in agreement with time planning data kept from the extranet. This information is restricted on the established period because of limitation of the synchronized data. In this way the following information are collected: actual dates of execution, measurement of the work developed, approval or disapproval of the inspection items of quality and work safety (reporting eventual not-conformities) and appointment of problems on the tasks execution.

One of the crucial points in the conception and development of the entire application was provide the perfect synchronization of the data persisted in the mobile device with the server of database managed on the web module. The web service technology and the standard XML were adopted for the data transfer between theses two bases due to its multi-platform nature and relative independence concerning to the communication.

Regarding the user interface for the mobile module it must highlight the prominent worry in the conception of the screens aiming minimizing the work of data input, simplifying the handling in construction sites (Fig. 4).

Fig. 3 Information flows for control task

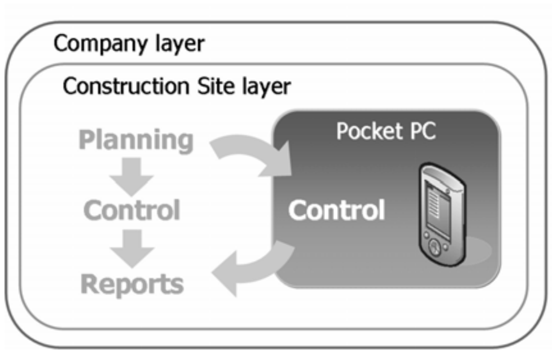


Fig. 4 Interface for mobile computer

CASE STUDY

The research project SIGEO was concluded with the development of the PLANTRACKER prototype and, as a continuation of the project, the beginning of the spin-off company operations (TechResult). The next steps were the conclusion of the final product development and its commercial exploration. Having this in mind, a new proposal for the execution of tests at some construction companies (TechResult's partners) has already been elaborated, contemplating the academic attendance of the Research Group (GRUPOTIC) of UFPR.

The prototype is now under tests at a medium size construction company on Curitiba, simulating the real implementation yet to be commercialized. For the related works to "simulated implementation", is being used the following order of events:

- User definition;
- Administrator training;
- Users training;
- Documents survey related to the planning and program implantation of quality control;
- General configuration at the company's stratum according to its necessities;
- Configurations at the project layer according to the site requisites for the case study;
- Casting data of the project's planning;
- Execution of project's control;
- Diffusion of collaboration tool's culture of use;
- Elaboration of implementation written report;

Many necessary points of adjustments on planning and control features were identified at the first work meetings. Once identified the need of these requirements revision, some fixes on the software were developed, in a parallel way to the configuration and implementation planning activities.

As a result of these actions the system will be improved with the inclusion of the following new features: Gantt graphic for planning and control, advanced filter for local-services and tasks, company's calendar definition, inclusion of predecessors and successors tasks resources, automatic calculation of start and ending dates of local-services and tasks for re-planning of activities, use of templates at planning phase, baseline to register original planning information, new options for resources' allocation control and adjustments in some offered reports.

CONCLUSIONS

This article presented the PLANTRACKER system, a prototype resulted from the SIGEO research project (funded by CT-INFO/FINEP-2002). The main characteristics of the prototype are: the use of extranets concepts in the development of projects´ portal, that have showed efficient in the improvement of communication; casting data through a web modulation; use of concepts of the Last Planner System in the planning performance and controlling of available tasks; the management of types of information related to quality control in workmanships – through standardizing services and activities, measurement and non-conformity written reports and identification of problems and execution of tasks control; and adopting a modulation of control in mobile devices as the solution for one of the main problems in the application of ICT in construction: the persistent dislocations for inspection and control.

From the technical point of view, the continuation suggested for the work here presented recommends the adaptation of web services and XML project for the IFCXML standard from IAI (Nisbet and Liebich, 2005), and molding budget's coefficients and costs control.

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Scheduling building projects in Colombia – by the use of Genetic Algorithms

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Abstract

The scheduling of construction projects in Colombia, until now, has been made primarily based on the knowledge of the engineers in charge and the use of specialized software designed to "show" a progress graph instead of minimize the net cash flow at every stage of the construction development.

This article presents the results of a project carried out by the authors at the Pontificia Universidad Javeriana. The project uses genetic algorithms to optimize the design of the construction schedule (progress chart) constrained by economic considerations. These considerations are: reduction of the total money borrowed by the construction company, the right time to start some activities and the need to meet the deadline for completion of the project.

Keywords

Project management, building construction , scheduling, genetic algorithms.

INTRODUCTION

Researchers in a number of countries have developed methods to optimize the scheduling of building construction projects. However, these methods work for conditions that differ substantially from the ones experienced by developing countries, like Colombia. The devastating economic crisis that Colombia went through during the late 90s forced new negotiation practices for buying land for building construction purposes.

This commercial behaviour had a direct impact on project planning. Currently, planning is far more dependent on the investment capacity as well as the liability of construction companies. Planning is also more dependent on the need to obtain greater profit in order to survive in the market place. Naturally the purpose of construction companies and organizations involved in building projects is to obtain an economic benefit from their activity. Unfortunately, the amount of possible solutions make it very difficult to give effective support to the decision making process.

Other researches have designed and tested Genetic algorithms to solve the scheduling construction problem. Unfortunately, in Colombia their development and use is still very

limited.
This article mentions three main elements involved in building construction projects. The project owner also known as developer, who may be the same constructor. The land owner who may or may not be involved in the project. And the buyer, the person interested in buying the housing unit being built by the owner of the project.

SPECIFIC COLOMBIAN ISSUES

During the last two decades of the 20^{th} century, it was very common to have projects that were first built and then sold. This generated an income and debit concentration in a few periods, resulting in a greater liability for construction companies.

During the first years of the 90s, Colombia began its process of economic opening. This brought substantial changes to the economic and social environment of the country. With this process, a transformation of the commercial practices occurred in the construction sector [Manrique, 2002]. Construction companies had to face sudden reduction of the value of their assets and lands, increase in the financial cost of their liabilities, and the difficulty of gaining liquidity through the sale of their properties. Because of this, several organizations went broke and the ones that survived changed their main objective. Instead of trying to obtain greater profits the new objective became to develop the project incurring in the less possible indebtedness or less possible investment. To achieve this objective, construction companies changed the practice of buying land to one where the risk was shared with the land owner. With this system, the land owner will give the land as a contribution, while the building company will be in charge of developing the project, the selling strategies and the construction itself. However, some land owners allowed construction to take place in their land but not to mortgage it to a financial entity, which made several projects unviable.

In the year 2002, Colombia had a period of economic reactivation and construction companies regained their investment and indebtedness capacities. Conversely, these companies learned that receiving the land as a contribution for the construction project is a good practice and that their investment or indebtedness capacities should be used exclusively for the construction process [Manrique, 2002]. Hence, the potential scenarios for building projects are strongly related to the indebtedness and/or investment capacities and the way in which the land is acquired.

The scenario where the builder has no credit or investment capacity takes place in countries with economies in recession like the ones in Latin America. When the resources availability is restricted, sales must support the project's cost. The objective becomes to minimize the investment and to generate enough revenue to make the project viable. Building projects have an income that depends on the selling tempo of the housing units. They also have debits because of the direct and indirect costs related to the construction of the building. The debit is conditioned by the building tempo which depends on the deadlines for delivery of the sold building units.

On the other hand, the scenario where the purpose is to maximize the profit obtained from the selling activities is typical of countries with economic stability, which are rare these days.

Nowadays, in Colombia two of the main characteristics of the building sector are related to the selling tempo and the way in which the land is acquired. The pace of sales is a result of the "know how" of the project owner. Consequently, project owner takes the decisions according to the gained experience and analysis of the historic information. Hence, the income is related to the selling rhythm and the way units are paid. This pace of sales signals the project owner when a down payments will be received, while the delivering deadlines indicate the construction tempo and the time at which the remaining amount will be received. After the buyer hands down the first payment, the remaining amount is usually a result of a credit he contracts with a bank; the bank will give the money to the constructor once the housing unit is delivered to the buyer. A common way of payment distribution is as follows: 30% as the first instalment by the buyer, and 70% paid by the bank. The buyer makes monthly payments to the bank for an agreed period of time until the mortgage is repaid.

There are basically two mercantile habits for the negotiation of the land between the owner of the land and the building developer. The first one is when the owner's contribution to the building project is the land, becoming an investor who shares the risk involved in the project with the developer. The second alternative is when the developer has the land as part of the inventory or buys a land, agreeing in a payment system and all the risk is taken by the developer.

Because of these characteristics, the project scheduling has a direct impact on the finances of the project. Additionally, the obligations to deliver the unit to the customer have an impact on the scheduling.

In order to model the described situation, the following assumptions were made:
1. The cost associated with each activity is uniformly distributed during its duration.
2. The cost per unit of labour and materials is constant for all the periods.
3. There are no limitations on the availability of labour and materials.
4. The debit caused by the activity is equally distributed during its duration.

LITERATURE REVIEW

The literature review did not reveal projects with similar scope or the same chromosome proposed in this paper. Several papers were reviewed, finding topics related to the building project scheduling with diverse objectives, using genetic algorithms as an optimization tool. [Hegazy and Petzold, 2003] proposed a practical model to estimate the scheduling and the control of the remaining activities in a dynamic way during the construction. [Leu et al, 2000] created a building project scheduling technique that smoothes the utilization of items (materials, equipment, machinery or tools) during all the periods of the project to meet established time and cost goals. [Leu and Yang, 1999] proposed the generation of a building project scheduling that smoothes the resources utilization in all the periods of the project, meeting time and cost goals, varying the duration of the activities and their beginning date.

BACKGROUND

Time Cost Trade Off (TCT)

The exchange between cost and time is a concept that describes the trade-off between the duration of the activity and the amount of non renewable resources committed to it [Vanhoucke, 2005]. The main idea is that there is an inverse relation between cost and the execution time of the activities. This concept is used with the purpose of diminishing the duration of the project, applying the inverse relation on the activities of the critical path. The costs of an activity may vary once the amount of labor changes, which also varies the duration of the activity.

Genetic Algorithms (GA)

Genetic Algorithms are a search technique based on the mechanisms of natural evolution proposed by Holland (1975). GAs use a set of feasible solutions for the problem called generation. Every solution for the problem is also called chromosome or individual. Improved individuals are generated by some genetic operators acting in the previous solutions. The most common genetic operators are crossover and mutation. Using these operators, the GAs explore different regions of the solution space. Individuals are selected for reproduction and therefore pass their characteristics to the next generation according to their "fitness". The fitness of an individual is a measure of how good a solution is. As a result, the best adapted individuals preserve characteristics of the best individuals from previous generations.

An individual is represented by a string of symbols denoted as a chromosome. The symbols represent the parameters, data, or relationships required to build a feasible solution for the built problem. Once a group of individuals is selected for reproduction, the generated children have pieces or substrings of their parents. Those children that inherit good characteristics from their parents, may have better fitness values and will have a better chance of "survival". New generations are thus continuously created until a stopping criterion is met. Common stopping criteria are a specific number of generations, or no improvement of the better solution in a pre-determined number of generations [Holland, 1975].

Mathematical Model

A mathematical model is used to show the situation. There are two alternative objective functions. The first one is intended to minimize the investment, and the second one is intended to maximize the profit.

Sets

$\mathbf{A}\ \{1,2,...,n\}$ project activities

$\mathbf{P}\ \{1,2,...,m\}$ time periods

$\mathbf{K}\ \{1,2,...,l\}$ kind of labour available

$\mathbf{J}\ \{1,2,...,y\}$ materials

$\mathbf{Z}_a\ ,\ \mathbf{Z}_a \subseteq \mathbf{A} \quad \forall\ a$ preceding subset activities for activity a

Parameters

I_p Income in period p

$D_{j,a}$ amount of material j used in activity a

U_j unit cost for material j

$R_{k,a}$ productivity labor k rate in activity a

V_k unit cost for labor k

Q_a amount of work to do in activity a

M_a longest duration time for activity a

N_a shortest duration time for activity a

i investor oportunity rate

Variables

$m_{a,k}$ amount of labor k for activity a

d_a activity a duration

$c_{a,p}$ activity a cost in period p

s_a activity a start date

f_a activity a finish date

e_p debit in period p

fc_p net flow cash in period p

fca_p acumulated flow cash to period p

cd_a activity a direct cost

Objective Functions

$$Maximize \quad Min\ (fca_p) \qquad (A) \qquad\qquad Maximize \quad \sum_{p=1}^{m} \frac{fc_p}{(1+i)^p} \qquad (B)$$

Constraints

$$fca_0 = I_0 \qquad\qquad fca_p = fca_{p-1} + I_p + e_p \quad \forall\ p \ \geq 1$$

$$fc_p = I_p + e_p \qquad\qquad e_p = -\sum_{\forall a} c_{a,p}$$

$$c_{a,p} = 0 \quad \forall\ p < s_a \qquad\qquad c_{a,p} = \frac{cd_a}{(f_a - s_a)} \times (p - s_a) \quad \forall\ p \mid f_a \geq p \geq s$$

$$c_{a,p} = 0 \quad \forall\ p > f_a \qquad\qquad cd_a = \sum_{\forall j} (D_{j,a} \times U_j) + \sum_{\forall k} (m_{a,k} \times V_k)$$

$$M_a \geq d_a \geq N \qquad\qquad m_{a,k} = \frac{Q_a}{(f_a - s_a)} \times \frac{1}{R_{k,a}}$$

$$f_a - s_a > 0 \qquad\qquad s_a - f_b \geq 0 \quad \forall\ b \in Z_a$$

The objective function **A** represents the scenario in which the indebtedness or investing capacity of the constructor is minimum. The minimum value of the cash flow in the periods of the project is maximized to find the scheduling that requires the less possible indebtedness from the investor. On the other hand, the objective function **B** refers to a case in which the aim is to maximize the net present value of the project, without taking into account the minimum availability of the resources that the constructor should have at any period.

Easy Implementation Tool for Project Scheduling Optimization (EITPSO)

EITPSO is the application developed as optimization tool for the scheduling of the activities in the building project. It uses two different objective functions specifically created for construction in the Colombian environment. This application uses Microsoft Excel as a data deposit, and Visual Basic for applications as a programming language.

The EITPSO Algorithm

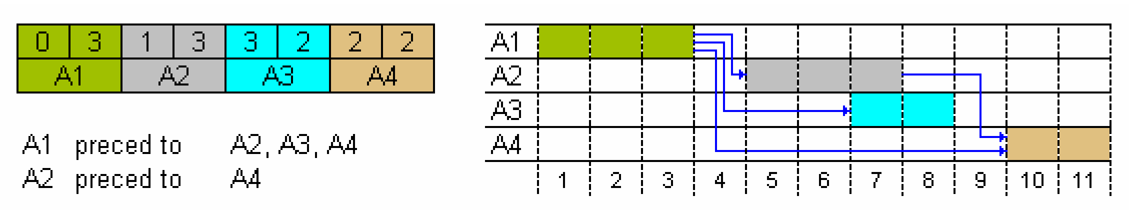
The following steps summarize the EITPSO algorithm. This pseudo code is very similar to GA; the differences lie in the definition and the decoding of the chromosome to generate a valid schedule.

1. Create the first population by the following two methods, and assign their fitness value f_u:
   1.1. randomly generating individuals to provide all the population.
   1.2. using best individuals found in previous EITPSO runs and randomly generating other individuals.
2. Assign to each individual a probability of selection directly proportional to its fitness value
3. Use tournament strategy to select pairs of individuals according to the probabilities calculated in step 3. Apply a crossover operator to the selected individuals to obtain their offspring
4. Generate a new population choosing the best individuals among the set of parents and offspring.
5. Choose randomly a small fraction of the new population and apply a mutation operation.
6. If the maximum number of generations is reached, then stop. Otherwise go to step 2.

Proposed Chromosome Structure

The proposed chromosome is defined as a sequence of genes, each consisting of a pair of integer numbers (g_1, g_2): The first integer (g_1) relates to the delay activity, its value ranges from 0 to a sufficient large number and the second one (g_2) relates to the duration of the activity, its value ranges from the critical time to the maximum duration. A graphical representation of the chromosome is shown in figure 1.

Figure No. 1



Selection Strategy

The chosen approach for selection of the parents was the roulette wheel strategy. In this strategy two individuals are chosen for crossover. An individual *u* has a selection probability (pr_u) defined as follows:

$$pr_u = f_u \Big/ \sum_{\forall z} f_z$$

Clearly, individuals with higher fitness values will have better chance of being selected to be the parents of next generation.

Crossover

The reproduction strategy used was the well known one-point crossover: Two individuals are selected for crossover. A crossover point on the first parent individual string is selected. All data beyond that point in the individual string is swapped between the two parent individuals. The resulting individuals are the children of the two parents. EITPSO uses this strategy to avoid breaking the schema representation coded in the chromosome. This is to preserve as much as possible the characteristics of the parents when passed on to the next generation [Whitley, 2001].

Mutation

The mutation mechanism implemented here randomly selects a predetermined number of genes in a chromosome for mutation. Typically such a number corresponds to a fraction of the total number of genes in the population. When a gene is selected for mutation, its value is replaced by a random number in its valid range (i.e. the interval between minimum and maximum duration).

Data Entry

The information needed for the EITPSO is introduced into specific Microsoft Excel spreadsheets. The required data are: building budgets, the selling plan of the project and the parameters of the GA. The budget is made of equipment, materials and labor (resources), unit price analysis - UPA -, activities and precedence between activities. The selling plan is made of the selling and delivery tempo. Each of resources has its unit cost, and its type: material or labor. Each activity is described with a code, a quantity of units to perform, a maximum and minimum duration, and a maximum delay. The UPA has the required items for each activity and their amount per unit of activity.

The indirect costs include aspects such as the monthly administration, the cost of the designs (architectural, structural, hydraulic, foundations, among others), as well as the costs associated with the delivery of the housing units, and others. At the moment of delivering the property to the customer, other costs take place such as the proportional payment of the block of the delivery unit, and special taxes and payments to third parties due to the selling commissions.
The estimated selling plan includes the percentage of the initial payment, the deadline for initial payment, the expected selling dates, and the amount of residential units to sell in each period.

Schedule Constructor

The building schedules obtained from EITPSO, are presented as a sequence of integer numbers that have no practical meaning. However, EITPSO allows activities, durations, delays and relations of precedence to be exported to Microsoft Project, so they can gain meaning for the company.

Case Study

With the aim of validating its results, EITPSO was used for the planning of several types of projects in Colombia, such as: the construction of an urban park in Bogotá and the construction of a residential housing complex in the city of Manizales, among others.

The project Portal del Bosque was one of the ones used for the validation, this building project consists of ten residential units of 51 activities each, and was developed in the city of Manizales during the year 2000.

The selling price of each unit was COP$ 98'080.122 and the agreed conditions between the customer and the constructor are as follows:

- First instalment: COP$ 29'424.036 (30% of the selling price)
- Deadline for payment of first instalment: 5 months (since the selling date)
- Final Payment at the delivery of the housing unit: COP$ 68'656.086 (70% of the selling price)
- The maximum period of time given for delivery of each unit is six months taken from the selling date.
- The minimum amount of units to deliver in each period is related to the number of units sold with the delivery deadline accomplished. However, each house can be delivered to its proprietary if he has given the first instalment and if the house construction has been finished.

Table 1. Expected income

The expected cash flow for the selling plan is shown in Table 1.

Period	0	1	2	3	4	5
Units	2	2	1	2	2	1
COP$	58'848.073	58'848.073	29'424.036	58'848.073	58'848.073	29'424.036

Financially, the project has a total cost of COP$ 829'528.661 COP (according to budget), an expected income from sales of COP$ 980'801.229 COP and for profit and unforeseen items an expected amount of COP$ 151'272.568. The land price is included in the total cost of the project.

It is important to remember that only houses with first installment completely paid can be delivered. This condition occurs because once the houses are delivered, they do not belong to the constructor, bringing a risk of not receiving the remaining value since there is no real guarantee. It is desirable to deliver each house as soon as possible, in order to receive the associated income as soon as possible, but it is advisable to begin the construction of a house only when there is certainty of its sale. To be precise, it is not recommended to finish a house if it is necessary to wait some time before delivering it. The parameters employed for the development of the EITSPO in order to obtain building schedules were: 50 generations, 2% of mutation, 80% of elitism.

Scenario with limited investment or indebtedness capacity

After running several times the EITSPO using as the objective function the minimization of the investment, it was found that the best scheduling required a maximum indebtedness level of COP$ 30’533.233 to build the project. With this indebtedness information, the return rate of the investment is about ***400 percent*** in less than one year. This result shows a very good return for the project owner. It proves how important the scheduling design is, allowing the constructor to have a return of almost four times the money invested in ten months.

The pace of deliveries obtained from the building schedule using EITSPO, indicates that the housing units must be delivered as shown in table 2.

Period	5	6	7	8	9
Units	2	2	2	3	1

Table 2. Expected pace of deliveries

Scenario with enough investment or indebtedness capacity

After running several times the EITSPO using as the objective function the profit maximization, it was found that the best scheduling has a net present value of COP$ 103’118.743.

The pace of deliveries obtained for the corresponding building schedule using EITSPO, indicates that the housing units must be delivered as shown in table 3.

Period	4	5	6	7	8
Units	3	1	3	1	2

Table 3. Expected pace of deliveries

The result shows that the pace of deliveries has a tendency to demand that all the activities are finalized as soon as possible. This implies the need of receiving all the income as closer to the beginning of the project as possible. The project schedule resulting by the use of this objective function has a duration of nine months.

CONCLUSIONS AND FURTHER RESEARCH

- This work demonstrates that it is possible to use a low cost application – a spreadsheet- and an optimization metaheuristic like genetic algorithms, to build a decision support tool for planning construction projects under specific conditions. In this case the specific conditions refers to the construction environment in Colombia.
- The economic benefits of the project schedules generated by EITSPO, for the project *Portal del Bosque*, showed that they are useful and adaptable to the characteristics of the Colombian environment.

- There are remarkable differences in schedules and pace deliveries for the two scenarios proposed. The differences are: the variability of the cash flow, the time needed to complete the project and the net present value of the cash flow.
- The proposed chromosome has important characteristics for the problem we were dealing with. This chromosome could represent the complete solution space. Additionally, it has the property of maintaining its feasibility after applying genetic operators without using repairing strategies. Another advantage is that the chromosome offers the possibility to represent the Time Cost trade-off concept for the activities in the project and the activities may be scheduled with a delay, if necessary.

The suggested topics for future projects are:

- To perform the modeling and formulation considering other special aspects in the Colombian construction context by using EITSPO. The goal is to allow the constructor to decide what the most convenient objective function is depending on his/her own situation.
- To change MS Excel platform, to use MS Project, so that EITSPO may use all its base structures as well as the utilities offered by MS Project.
- Finally, it will be interesting to try other optimization strategies inside the genetic algorithm implemented (i.e. use of tabu search as a special case of mutation operator, etc.)

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Rethinking the Critical Path Method for Construction Project Planning

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Abstract
This paper reports on an on-going project aimed at developing a universally applicable planning methodology that integrates and exhibits the best characteristics of existing planning tools (simplicity in use, versatility in application, provision of user insight into the functioning of a project, and effective optimization of the project objectives). The paper reviews various features of existing planning tools, and proposes a synthesis of many of these ideas, along with some enhancements. The overall aim is to provide a single tool more suited to the demands of present-day construction project management. Specifically, the developments are concerned with: (i) the way in which a model is structured (simplifying model design and understanding); (ii) redefining the way in which tasks interact and depend on each other (so that the approach is no longer limited to a schedule-centric perspective with interactions occurring at discrete points in time); (iii) providing a more realistic representation of resources and their dependencies to reflect the way work may actually be carried out on site (such as the use of flexible and divisible crews); (iv) the visualization (graphic representation) of both the model structure and work progress in a integrated format; and (v) optimization of the overall project objectives. The principles of the existing and proposed new approach to project planning are discussed and rationalized, and application of the new approach is demonstrated and compared to existing planning methodologies for some example construction processes.

Keywords
Project scheduling; Project control; Project optimization; Critical Path Method; Resource optimization.

INTRODUCTION

A variety of techniques have been developed over the decades to assist in the planning, monitoring and control of construction projects. These include, the Critical Path Method (including precedence networks and linked bar chart formats) which are the most common methods and are used for planning projects where the tasks are discrete in nature, construction simulation [e.g. Halpin and Woodhead, 1976] which is not very widely used but is very versatile at modeling low-level repetitive tasks, and the line-of-balance and velocity diagram methods which are designed for modeling linear construction projects where the tasks are predominantly repetitive or continuous in nature [e.g. Matilla and Abraham, 1998]. Each technique is based, of course, on a different set of modeling principles, providing each with a unique set of advantages, disadvantages and scope of application. A problem, however, is that most construction projects include features that extend beyond the boundary of application of the individual tools. Moreover, for historic and/or logical reasons, the existing tools include many assumptions and simplifications that restrict their ability to model many situations. This paper reports on on-going work that attempts to synthesize the best features from the broad spectrum of existing planning tools (and to enhance those features where possible), with the objective of providing a powerful, simple-to-use framework, applicable to all construction projects.

HIERARCHICAL MODELING

A hierarchical (structured) approach to modeling has long been recognized in systems science as a powerful way of developing and defining representations of very large and complex systems. In essence, a hierarchical approach forms a representation of a system by decomposing it into categories of tasks and subtasks, in a top-down manner. For construction, the decomposition into tasks should be building-component oriented (as opposed to say material-type, trade, or division oriented) since this reflects the way in which buildings are assembled. The main advantages of a hierarchical approach to modeling are simplified model development and revision, fewer errors in the model design, and better insight into the system being modeled (since the model provides understanding at different levels of abstraction) [AbouRizk and Hajjar (1998), Huber et al. (1990), Ceric (1994)].

To an extent, the concept of hierarchical modeling is already adopted in construction project planning in the form of Work Breakdown Structures (WBS's) and is even implemented in some project planning software packages. WBS's are, however, simply a classification or grouping of work tasks (to make the model more readable) and are not an integral part of the structure and operation of the model, that is, they do not help define the logic of the model or its constraints.

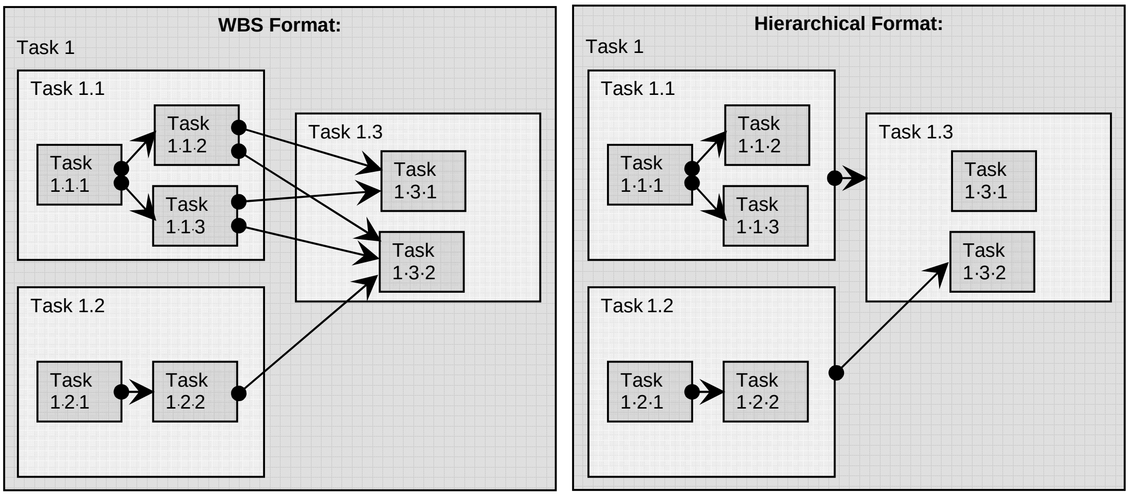


Figure 1: Comparison of the WBS and Structured Approaches to Defining the Logic of a Task Network

Consider for example, the sample project plan shown in Figure 1. The left side of the figure shows the project organized within a conventional WBS format, while the right side shows the equivalent project organized using a fully hierarchical approach. For both approaches, each block represents a task (or sub-task) and each link represents a dependency (timing for most planning models) between tasks. A fundamental difference, however, is that the hierarchical approach allows the dependencies to be defined between tasks at any level in the network (the scope of dependency of a link being all subtasks within the task to which it is connected) whereas the WBS approach requires all logic to be defined at the lowest level tasks. In this example, the Tasks 1.3.1 and 1.3.2 require Tasks 1.1.2 and 1.1.3 to be completed, and Task 1.3.2 requires additionally Task 1.2.2 to be completed. Clearly, the hierarchical approach reduces the total number of links required to define the logic, thus making the plan easier to read and modify. Also, more subtly, the hierarchical approach provides a better insight into the logic of the project by indicating generalized relationships (those at higher levels of abstraction). For example, it is clear from the hierarchical format that the high-level component represented by Task 1.3 is fully dependent on the completion of the high-level component represented by Tasks 1.1, and partially dependent on completion of Task 1.2.

Interestingly, a computer-based implementation of this approach could readily determine the simplest set of hierarchical links that would achieve a given logic. Thus, a planner may input links at an unnecessarily low level in the structure (in an extreme case, this would be to input all links at the lowest level tasks) and the software would reduce these to the minimum set of higher-order links. Moreover, the computer implementation could be readily programmed to identify and suggest new groupings of tasks that would further reduce the number of links (such as illustrated by the dashed boxes in Figure 2) – such groupings may have some physical meaning and value in the organization of the project that the planner had not previously identified, in addition to enhancing the readability of the model's logic.

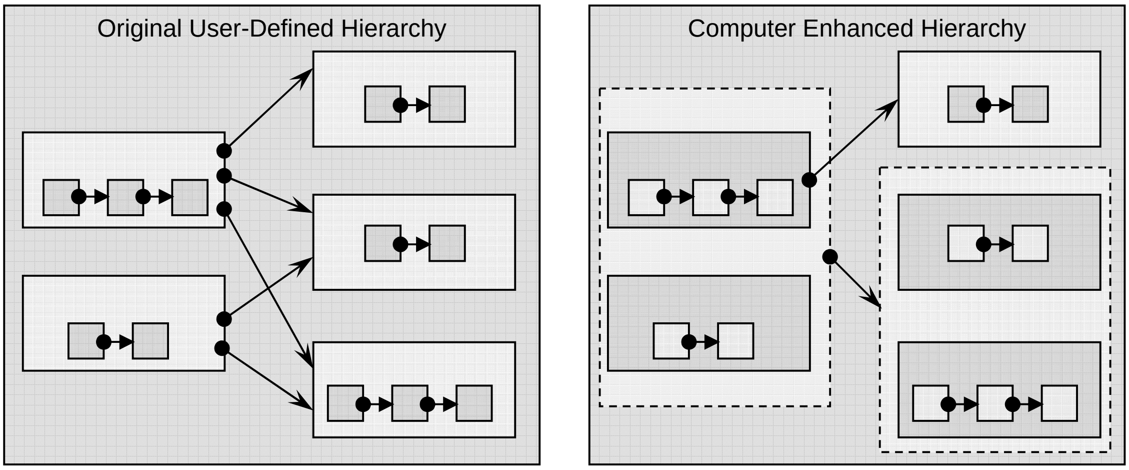


Figure 2: Computer-Based Optimization of Project Hierarchy

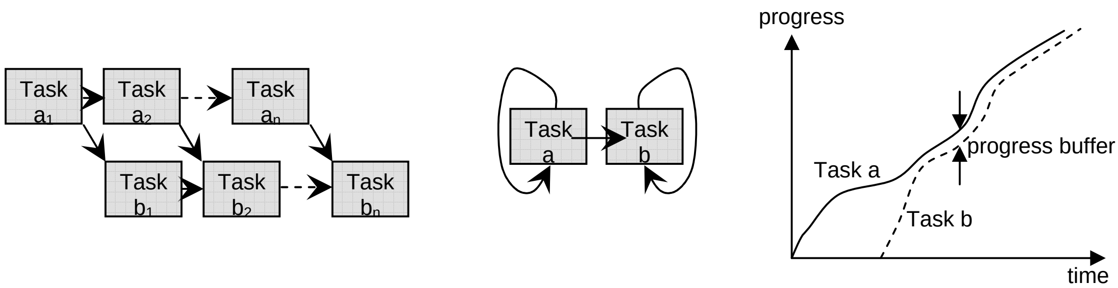
CONSTRAINTS AND FREEDOMS

The progress of work on a project is partially determined by constraints on the system. The constraints are any logical requirements that must be satisfied, and range from limitations on the availability of resources (equipment, money, space, etc) through to a requirement for one task to maintain a minimum amount of work in advance of another task (a distance or time buffer for example). Any planning methodology must allow all significant constraints to be taken into account.

In contrast, all projects have a number of freedoms in the way in which work may be executed. For example, some tasks may not be able to occur at the same time but might have the freedom to be executed in any sequence. Other tasks may have some leeway in terms of the numbers of resources they need to perform the work, such as flexible crews where all members may work together on a single task for a while and then later split to perform concurrent tasks. The freedoms in a project create the need for optimization, that is, determining the choice from within the freedoms that will satisfy the project objectives most effectively. For the proposed system, optimization of a project plan would make use of Genetic Algorithms, due to the ability of these techniques to handle problems that comprise both discrete and continuous parameters and complicated system structures and dependencies.

Task Dependencies

Task dependence (that is, where the progress of a task(s) is limited in some way by the progress of another task(s)) is the most common form of constraint considered in planning. Figure 3 illustrates the different methods used for defining task dependency between two continuous processes using: (a) precedence networks; (b) simulation diagrams; and (c) velocity diagrams.



(a) Precedence Network (b) Simulation (c) Velocity Diagram

Figure 3: Alternative Types of Dependency for Three Common Planning Methods

In the precedence network approach (see Figure 3(a)), the arrows indicate event dependencies between tasks, typically used to indicate that the preceding task must finish before the successor task can start. Less commonly, the dependencies may be between the start events of both tasks, the finish events of both tasks, or even the start event of the preceding task and the finish event of its successor. Also, in a precedence network, each task is executed just once.

For most simulation methodologies used in construction, the arrows in a diagram show the flow of resources between tasks, indicating that a task cannot start until some combination of resources are available at its input (typically with either an AND logic or an Exclusive-OR logic). Task 'b' in Figure 3(b), for example, requires some combination of resources from both tasks 'a' and 'b' in order to be functionally the same as the precedence network. In contrast to the precedence network, the simulation approach allows tasks to be repeated many times, possibly by different resources performing the task concurrently.

For a velocity diagram (such as that shown in Figure 3(c)), the dependence between tasks is imposed by a buffer between the respective progress curves. The buffer can be time oriented (giving a minimum advance in time that must be maintained by the preceding task over its successor), or it may be progress oriented (giving a minimum advance in quantity of work that must be maintained by the preceding task over its successor) as shown in this figure.

Each of the above three approaches has its own advantages. The precedence network approach is very simple to use, but is not well suited to projects where many of the tasks are repetitive in nature, and is not very versatile being limited to AND-based dependencies between task start and finish events.

Simulation is the most versatile allowing relatively complicated logical dependencies to be developed between tasks, but these dependencies are limited to discrete task events. The velocity diagram approach is simple to understand and allows continuous dependencies between the progress of tasks, but it lacks the versatility of the simulation approach and requires all tasks to operate along a single sequence.

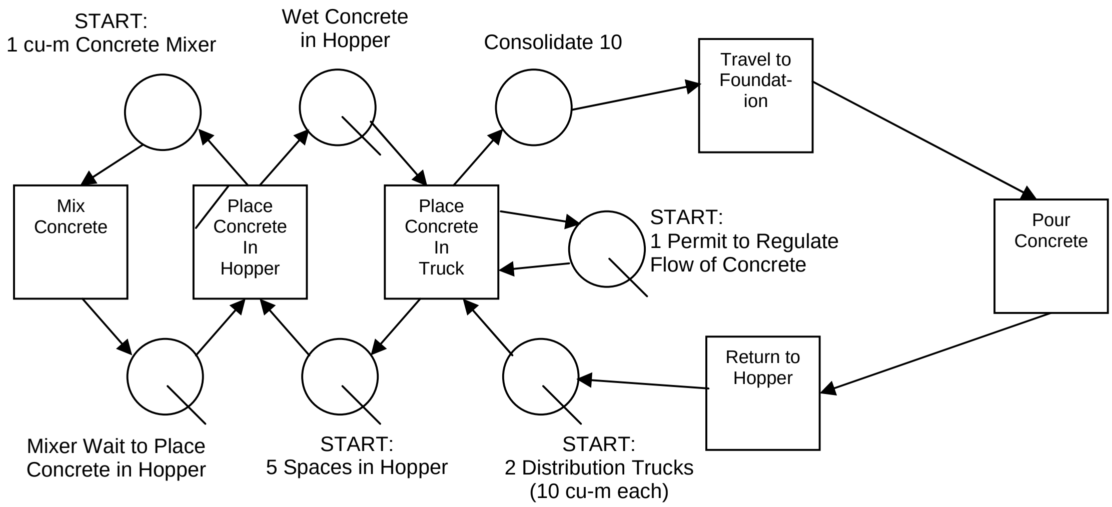
Simplicity in use yet versatility (and thus accuracy) in modeling are ideal attributes for any planning tool. In the case of task dependencies, this balance can best be achieved using an extension of the velocity diagram technique. For the proposed system, dependencies can be defined between any tasks (and at any level) that limit their relative progress, and for any measure of work (time, distance, units completed). The advance in progress may be specified to be above or below a given value, and their may be more than one such dependency between two tasks. Thus, it may be defined that task 'A' be at least 10 m behind task 'B' but no more than 25 m behind. Another variant would be for the progress of the tasks to flip-flop between the limits so, for example, task 'A' may operate until it is 25 m ahead of task 'B' but then wait until task 'B' catches up to 10 m distance. This approach has the versatility to model any dependency available in the precedence network, velocity diagram, and the commonly used simulation diagram approaches. Figure 4 compares the proposed representation with that of the CYCLONE system [1] for a concrete production and distribution system. The system represented comprises a 1 cu-m concrete batching plant, a 5 cu-m hopper for storing wet-concrete, and two 10 cu-m distribution trucks. In the proposed new approach (part (b) of the Figure), most of the dependencies would simply specify that preceding tasks must be completed before their successors can start. However, the link between the middle-level tasks would specify that 'Concrete Production' must be between 0 and 5 cu-m of wet concrete ahead of 'Concrete Delivery'. This would impose the logic of a 5 cu-m wet-concrete hopper between these middle-level tasks, equivalent to that of the CYCLONE model.

Structured Resources

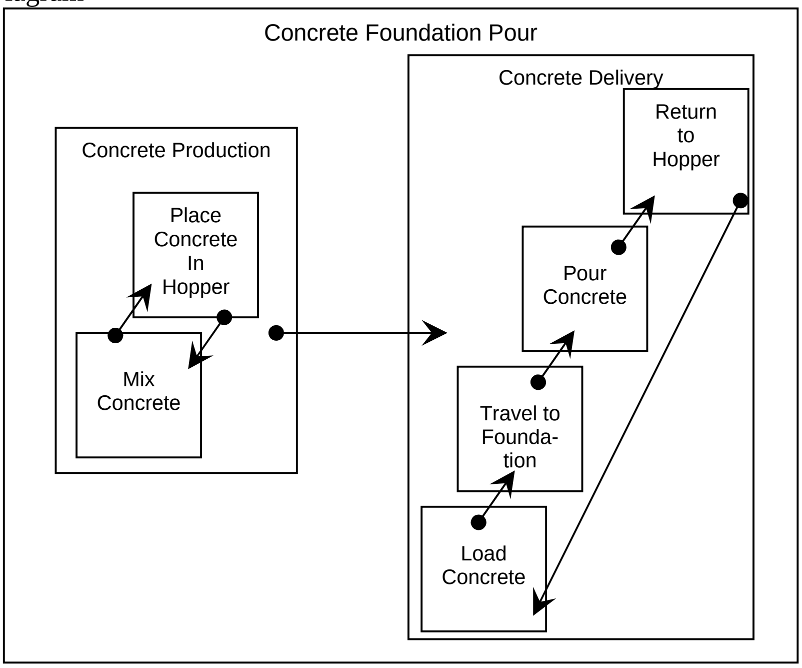
A second main class of constraint in a project (following task dependencies) is that of resource availability (equipment, labor, space, materials, work completed, money, etc). In the proposed system, a structured approach to defining resources is adopted (similar to that for defining the tasks, in that a resource may comprise several sub-resources and sub-sub-resources. Each resource, or sub-resource, may be defined as an actual quantity required to complete the task or It may be defined as a range of values. The range of values provides a degree of freedom within the model creating an opportunity for project optimization, and facilitates consideration of factors such as flexible crews – for example, the number of general laborers in a crew may be allowed to vary within a specified range and thus crew members would be able to drift between tasks on an as-needs basis.

VISUALIZATION OF PROJECT STRUCTURE AND PROGRESS

Visualization of progress in a project is key to understanding the effectiveness of a given plan, the actual performance on site, identifying possible problems, and proposing solutions to problems that will satisfy the project objectives. While precedence diagrams and simulation diagrams are useful for understanding the work involved in a project and the dependencies between tasks, the velocity diagram provides the most insight into the impact of task relationships on project progress. Velocity diagrams can, incidentally, be produced as output from simulation models. Precedence diagrams can (following a time analysis) be used to generate project progress curves, but these plots do not associate progress with the individual tasks, and thus provide limited visual insight into the impact of those tasks on the performance of the project.



(a) CYCLONE Diagram



(b) Proposed Representation

Figure 4: Concrete Production and Distribution System for Foundation

The hierarchical structure of a project plan in the proposed approach enables visualization of progress at many levels of detail and in a format similar to that of velocity diagrams. The project task structure can be graphed to scale with, for example, time shown in one direction and some measure of progress (such as cost or activity-days) plotted in the second direction. An example of this is provided in Figure 5 for part of a plan for an office complex. Progress is plotted in this scaled manner within each task box (cost versus time), and these task boxes can be peeled away to view progress at the higher levels in the project. This way, a user can, in an interactive environment, explore project progress at all required levels of detail. For sections of the project that are linear in nature (such as pipeline

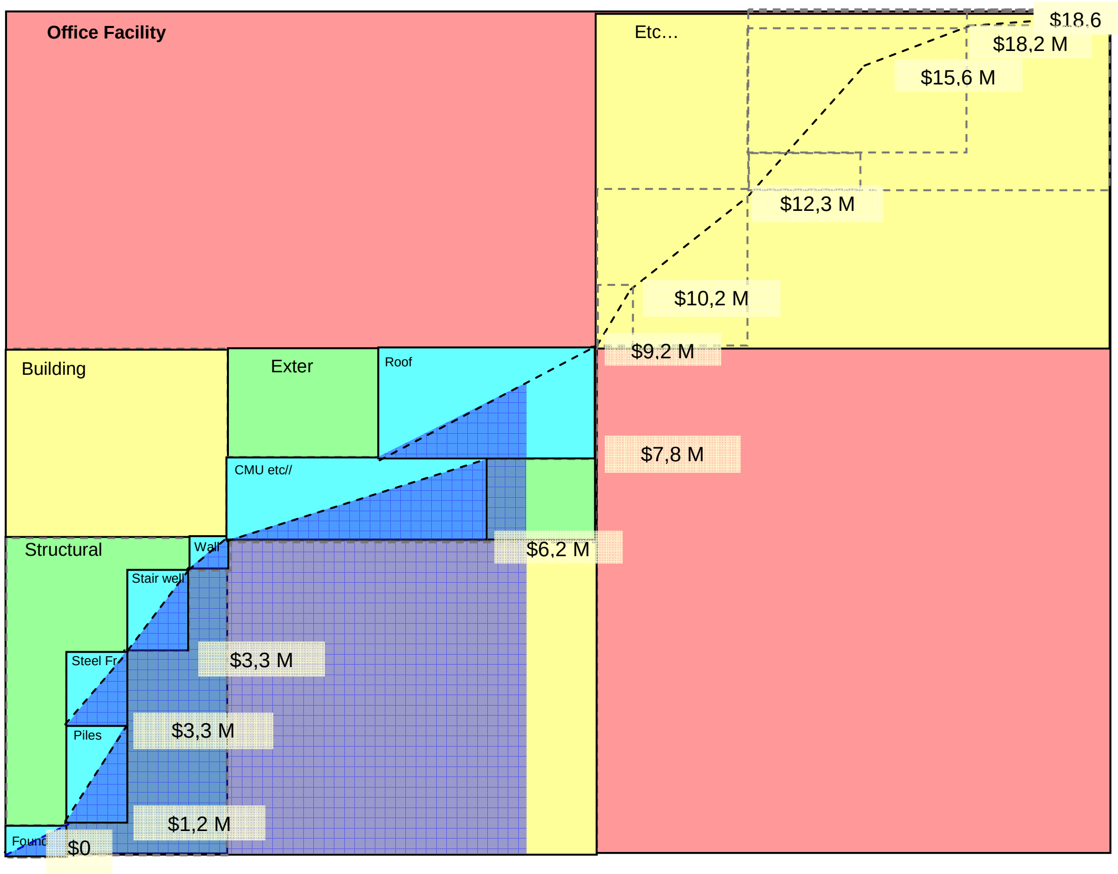


Figure 5: Example Hierarchical Visualization of Planned Progress of Work for Part of an Office Complex

construction, tunneling, or highway construction) where several tasks follow each other on the same section of the project, the progress plots would result in something very similar to a velocity diagram.

Finally, the hierarchical approach is also conducive to visualization of a project utilizing the ideas of 4D-CAD whereby a facility and its construction progress can be viewed within a dynamic walk-through environment. This is made possible since the task-hierarchy is component-oriented with each task representing a physical part of the building (at different levels of detail), and therefore has a one-to-one relationship with the architectural plans. Indeed, many 3D-CAD systems [Issa et al., 2003] now enable designers to implement the design in a hierarchical framework as such and would thus be conducive to integration into a 4D-CAD environment using the proposed planning methodology.

CONCLUSIONS AND FUTURE WORK

This paper has outlined a new approach to project planning, monitoring and control that integrates the ideas from a range of alternative planning tools and from systems science, with the objective of providing versatility in modeling all types of construction work, maintaining simplicity in use, and maximizing visual understanding of a project.

Work is on-going developing detailed project plans using this system for a variety of project types, including underground utilities operations (water pipelines, sewers, gas pipelines, and electrical conduits) for large residential projects, high-rise condominium projects, and medium-rise office facilities. The objective of these studies is to determine the successes and limitations of the proposed planning method in the real-world, and to determine refinements that increase its value as a planning tool.

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How Construction Project Managers use Their Time: Empirical Evidence in Chilean Construction Companies

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Abstract
A common complaint of construction project managers is the lack of time for a more complete dedication to what they consider are their main duties. They usually work long days where they experiment many interruptions and often have to attend urgent requirements that prevents them from finishing work that they consider important. Considering this situation, a group of six construction contractors participated in a study to obtain objective information about the way construction project managers use their time. The results of the study are being used to develop organizational strategies to make more effective use of their time.
The methodology used for the study included one focus group, a time management workshop and a detailed real time monitoring of activities of 7 projects managers from 4 companies. This allowed identification of the main activities carried out, communications means, dysfunction in time use and their sources and a number of other aspects useful for comprehensive diagnostic of the subject. The paper reports the results of this study and provides recommendations for companies and professionals to improve the use of project managers’ time.

Keywords
Project managers, time use, time management, personal effectiveness, lean construction.

INTRODUCTION

In the construction industry it would be unthinkable to conduct a construction project without a project manager (PM) (Udo and Koppensteiner, 2004), not only because there is a demonstrable link between the competence of top team members and the overall performance of the organization (Kakabadase, 1991), but also because it is stated that a project’s success depends directly upon the leadership qualities of project managers and their ability to bring the best out in their team (Daintly et al, 2005; Dulaimi & Langford, 1999; Jaselskis & Ashley, 1991). For this reason, given the technological and cultural changes that have rapidly taken place in the last decade, investigators and practitioners have developed a special interest in improving the knowledge of the PM’s work, in order to support his performance and therefore obtaining more successful projects.

In this sense, most of the investigations have been centered in studies of leadership and in defining the necessary skills to carry out that position, understanding as skill a series of different characteristic, behaviors, and traits necessary for effective job performance (Abraham et al. 2001). However, as

Shing-Tao (2001) states, “to improve the performance of engineers, it is necessary to study what they do." For this reason (given the current condition in this study field) the present work seeks to provide empirical evidence related to the PMs’ time use in Chilean Construction Companies, identifying the principal tasks carried out during the day, the people to whom they frequently speak in order to fulfill their job, the communication means used and the time use dysfunctions caused by themselves and by external agents (organization culture, environment, incapability of the work team, among others)

The study was originated due to the concern of six Chilean construction companies that currently work in implementations of “lean construction” practices (Alarcón, 1997)**.** These companies consulted the authors in order to obtain objective data about the activities carried out by their PMs. The motivation originated in their managers’ frequent complaints related to the lack of time for a more complete dedication to activities that add value to their job. PM’s also argue that their workday is too long, characterized by frequent interruptions and urgencies to resolve. On the other hand, in a study carried out by the authors in the same companies (Alarcón, Pavez, Bascuñán and Diethelm, 2005), a group of PM’s rated the “time management” skill among the most important for their jobs and the *most difficult to put into practice*. The research methodology included a focus group with PM’s, a time management workshop and a three day follow-up to 7 PM’s in which each one of them had to write down every 15 minutes the tasks carried out, obtaining a total of 21 days for analysis purposes (a month’s work approximately).

RESEARCH DESCRIPTION

Research objectives

The main objective of the study was to provide empirical evidence concerning PM’s time use, so as to support improvements on their performance. In order to achieve the objective the following questions needed answers: ¿What does the typical workday of a PM consist of? ¿With what people do they relate to? ¿What communication means do they use? ¿Which are the tasks (activities) that consume most time? ¿Are these tasks (activities) related to the ones that should be carried out? ¿What kinds of dysfunctions in the use of time are present in their work?

Research methodology

The studies of work time use have their origins at the beginning of the 20th century with Taylor’s (1911) first works, in an attempt to distribute work rationally between executives and workers optimizing productive work (Rodríguez, 2004). Since then, several methodologies have been developed in order to diagnose the use of time according to the desired objective.

To study time use in executives (the case of PM’s) – which are people that are able to use time at their own discretion – there are different tools that can be used (Rodríguez, 2004), among them: (1) direct observation of the executive’s work, accompanying him/her during several complete workdays; (2) an executive’s personal log of the tasks at 15 to 30 minute intervals; (3) interviews to executives with a guideline in which they are asked to assign percentages of their time dedicated to the accomplishment of different tasks; (4) gather a group of executives and ask them to discuss their time management and the difficulties that normally arise; and (5) interviews to executive assistants about their bosses’ time distribution. In the present study, techniques (2), (3) and (4) were used in two stages (see Table 1)

Table 1. Research methodology description

Stage	Objetive	Description
Preliminary Diagnosis	Obtain global information about the problem and generate a discussion about the PM's work.	The technique used for the development of this stage was a combination of techniques (3) and (4) mentioned above, in which a "focus group" with the PMs was developed and where the main tasks in which they were involved were established. Later on, an evaluation form was developed in which the PM had to assign a time percentage dedicated to each task during the week and also evaluate the task relevance by marking with an X whether he/she should have done it or not. In this stage 16 people were involved.
Time study and analysis	Study the problem in its depth, applying techniques that allow to obtain more objective data.	The technique used in this stage of the study was a combination of techniques (2) and (4) mentioned above. In order to accomplish this, a time management workshop was done for PMs in which problems related to time management were discussed in detail. A three-day follow-up was also done to seven PMs in which each one of them had to write down his/her tasks every 15 minutes, therefore obtaining a total of 21 days for analysis purposes.

Sample descripction

The sample was segmented in two parts (due to the study division) according to the corresponding stage: the first stage includes 16 PMs from 6 different companies while the second one includes 7 PMs from 4 different companies. A special characteristic of the participating companies is the fact that all of them are currently implementing "lean construction" practices. The areas in which they work are: housing, high rise buildings, light industrial facilities and civil works. The sample detail is presented in Table 2, in which "S1" represents the first stage and "S2" the second stage.

Table 2. Sample description

Tipe of project	Company 1		Company 2		Company 3		Company 4		Company 5		Company 6		Total	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Housing	1	1	-	-	-	-	-	-	1	-	2	1	4	2
High rise buildings	3	2	1	-	2	1	-	-	4	-	-	-	10	3
Light industrial facilities	-	-	-	-	-	-	-	-	-	-	1	1	1	1
Civil works	-	-	-	-	-	-	1	1	-	-	-	-	1	1
Total	4	3	1	0	2	1	1	1	5	0	3	2	16	7

RESULTS

General analysis

In general terms, with the data obtained from the measurements, it is possible to identify 5 characteristics present in the PM's work: (1) great variety of themes that he/she must handle simultaneously, generally associating each one of them with a quick decision making; (2) extensive workday, averaging 11.3 hours per day; (3) great number of different people to whom he/she must relate to (in some days more than 15, without considering the people that work inside the project); (4)

great number and intensity of communication tasks that he/she must carry out everyday, averaging nearly 75% of his/her work-time interacting with other people; and (5) absolute responsibility of the project's outcome, even replacing the tasks of subordinates in extreme cases such as an illness.

PM's most time demanding activities

A first approach in relation to the study theme was to define what activities demanded most of the PM's time. In order to do that, the measurements were analyzed and the tasks were classified according to three parameters: activity type in terms of its relation to a particular function or technique (planning, control, technical analysis, negotiation, conflict solving, etc), person to whom the PM interacts with while the activity is executed (subordinates, subcontractors, owner/OTI, others), and communication mean used (see Table 3). The analysis showed that the tasks which consumed most of the work time (almost 50%) were:

1. *On-site planning*. Represents every activity related to the project planning at any level (strategic, tactic and operational).
2. *Meetings with the owner/OTI (Owner Technical Inspection)*. Include all activities that imply a meeting (formal or informal) between the PM and the owner or the OTI. Meetings with the owner are generally formal in which economic issues are discussed while meetings with the OTI have a more technical character.
3. *On-site work supervision and reception*. Including all activities oriented to assuring the compliance of standards and deadlines.
4. *Job meetings*. All PM's meetings with the key project positions, including architects, structural engineers, risk prevention officers and subordinates.
5. *Coordination meetings with subcontractors and suppliers*. These meetings have a mainly technical character and only subcontractors and suppliers participate in order to coordinate subcontracted jobs and deliveries (suppliers).
6. *Revision and updates of technical project data*. This activity is mainly deskwork and is related to the revision and update of all of the project's technical documentation (project book, quality assurance protocols, security documentation, material specifications, plans, etc).

Frequent Interlocutors and Communication Means Used

A second analysis includes a replica of the analysis carried out by Henry Mintzberg (1990) and Luis Enei (1988), adapted to the construction industry. Both studies intended to understand the directive's work by carefully following for several days each and every one of the activities they carried out, focusing their analysis, among others, in his/her frequent interlocutors and the communication means employed. The detail of this analysis is presented in Figure 1, highlighting:

1. *Frequent Interlocutors:* Most of the PM's relationship time is invested, as expected, with his/her subordinates (36%) as he/she holds the highest hierarchical rank; secondly are his colleagues or "laterals" (20%), which are people related to the project in an advisory manner (among them are architects, structural engineers, and central office personnel that advises the PM in specific topics); in third place are the subcontractors (16%) that, depending on the stage of the project and the company characteristics, can hold up to one third of the PM's relationship time; finally, the last important interlocutor is the owner/OTI (14%), which is the client receiving the service. This type of analysis cannot explain entirely the different themes discussed because it does not describe the way they relate to the central objectives of the PM (importance v/s urgency) and neither can

incorporate the inherent subtleties of communication, so it presents a good opportunity for future research.

2. *Communication Means*: Figure 1 shows that meetings consume in average nearly a third of the workday (35%) and sometimes they can even take over more than half of it. According to this it can be inferred that one of the most effective means to enhance the current use of time is to train PMs in effective meeting management. This training could allow to achieve a wide variety of related objectives such as: contribute to an effective communication, lead to greater productivity, build up team spirit, increase individual morale and reduce misinterpretations (Kliem and Ludin, 1992). In second place is the deskwork (25%), which was described by the authors as an independent communication task, which means that it is not generated from the relation with other people (as the other tasks do); within this task are included all tasks related with documentation analysis, updating and checking information, meeting preparation, among other things; it is a strictly personal analysis concerning the project execution. Finally, it is interesting to emphasize the fact that on-site visits only consume a 7% of the workday, which indicates that the PM delegates the execution tasks to other professionals.

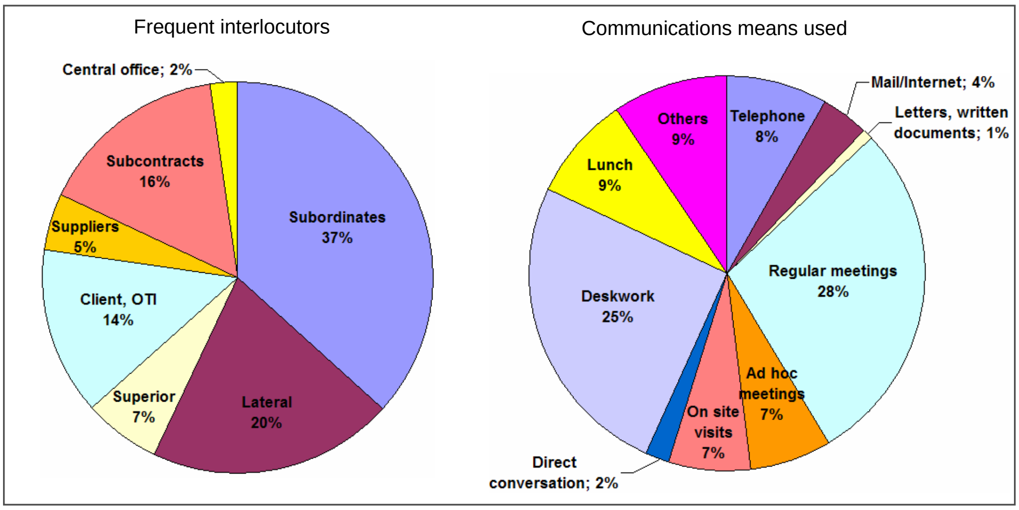

Figure 1. Frequent interlocutors and communication means used

Time use dysfunctions

A dysfunction is understood as any factor and/or situation that is ominous for an effective time use (Casado, 2002). In the study, the detected dysfunctions come mainly from a qualitative analysis of discussions with PMs (in the activities developed throughout the study) and from an organizational diagnosis made by the authors in the same companies (Alarcón, Pavez, Bascuñán and Diethelm, 2005). In order to categorize the time use dysfunctions Casado's (2002) proposed classification was used, in which is stated that these may come from: directive's behavior, organization structure, team and environment. An explanation of each one of them follows:

1. *Directive's behavior*: In this type of dysfunction the problems that most frequently arouse were the inability to say no, lack of prioritization, unclear perception of their main functions, problems

with delegation capacity and lack of qualification in management's "soft" subjects that empower the time use (time management, leadership, communication, etc).

2. *Organization Structure*: In this type of dysfunction it can be highlighted that the majority of organizations use hierarchical structures centered in the administrator's qualities (leaving aside the constitution of solid work team), which not only widens the range of activities that the administrator must develop but also increases the inefficiency in delegation and reduces the time he/she spends in his/her main functions. At the same time, a vague definition of roles and responsibilities exists, generating role duality with often effort duplication.
3. *Team*: In this type of dysfunction, the principal problems detected were the lack of qualified personnel to support the PM's work in certain specific functions (being supplying the most critical one) which makes delegation more difficult; an unbalance between the load of work and the team's capacity to undertake it, implying frequent workday extensions; and a highly boss dependant team because in most of the companies, the PM's position is empowered at the expense of the rest of the project team.
4. *Environment*: With respect to the environment, the principal problem detected was the organization culture effect in the time use of the PM's position. In this sense, it was mentioned that staying until late hours was well seen (in fact, there are PMs that were telephoned after 8 o'clock in the evening by their company's senior board), that projects are to be done under pressure and that the work development is highly dependant on the PM.

Table 3. PM's time demanding activities (descending order)

N°	Activity Description	Minutes	Percentage (%)	Cumulative Percentage (%)
1	Project planning	1.122	9,3%	9%
2	Meetings with owner/OTI	1.080	8,9%	18%
3	Task supervision and reception	1.050	8,7%	27%
4	Project meetings	895	7,4%	34%
5	Coordination meetings with subcontractors and suppliers	840	7,0%	41%
6	Project's technical documentation revision and update	695	5,8%	47%
7	Negotiation with subcontractors and suppliers	690	5,7%	53%
8	Activities not related with production	525	4,3%	57%
9	Quality assurance meetings	480	4,0%	61%
10	Contract documentation checking	450	3,7%	65%
11	E-mail, mail and personal agenda checking	442	3,7%	68%
12	On-site work coordination	440	3,6%	72%
13	Meeting preparation	420	3,5%	76%
14	Meetings with headquarters (meetings with superiors)	415	3,4%	79%
15	Material and equipment request ,tracking and control	375	3,1%	82%
16	Project performance control	355	2,9%	85%
17	Others (activities 17-27)	1.808	15%	100%

CONCLUSIONS AND RECOMMENDATIONS

The effectiveness of the directive depends in a good way of the knowledge about his own work (Mintzberg, 1990**)**, which is not only important for him/herself, but for everyone who is inserted in the industry due to the great influence the administrators exert in the other actors to whom they relate. In this sense, the present work approaches this problem and allows to identify clear behavior rules, the main activities developed and specific aspects that can be improved, which can serve as a baseline for future investigations.

In the case of PMs, one of the main challenges consists in realizing the eminently social character of their work, since their work is characterized by a great number of interrelations (approximately a 75% of the work) and intensive communication activities, in which their social skills play a fundamental role and impact their performance in a significant manner. In this way, a socially skillful PM may build more motivated teams, have better negotiation results and improve the communication between the different project actors. This social characteristic of the PM’s work (more relevant than a technical one) implies a redefinition of the position in terms of his responsibilities and results, as it encourages inquiring the causes (main aspects) that trigger the consecution of successful projects. This situation, which has been poorly approached by the industry, has become more relevant in the last years with the generation of innovating researches that invite to view projects from another perspective, giving more relevance to the commitments generated through conversations (Howell et al, 2004; Macomber and Howell, 2003; Flores, 1997).

In relation to the above, another relevant aspect of the PM’s work is to clearly define what are his/her key functions in the project, so as to invest time in activities that add value to his/her performance. This objective compatibility not only helps to improve his/her personal effectiveness, but it also helps him/her to make time available for innovation and productivity improvement, which currently are not available.

One of the greatest challenges of a Company’s top management is to train highly qualified PMs, retain and motivate them, in order to keep its know-how and assure their permanent contribution to the company. In this sense, one of the most conflictive issues is the extensive workday they have to cope up with, which can produce stress, burnout professional employees or create personal conflicts such as a trade-off between time dedicated to the family and the time dedicated to work, being family in many cases one of the most important aspects of personal fulfillment. In this sense, many of the excessive workday problems have their origins in unconscious pressures exerted by the company’s top management deeply rooted in the organization culture, such as, associating time of work as a status symbol, or rewarding (even in an unconscious way) the excess of work. In order to solve this problem it is recommended in first place to discuss the issue openly; generating solutions in agreement with the challenge, such as the creation of proper indicators based on the pursued objectives and not only based in productivity; and taking proper measures that encourage a compatibility between personal and professional time, such as the limitation of the workday.

Finally, given the existing problems related to the work team it is essential, in order to improve the PM’s work, to provide him/her a solid supporting project team, so that the PM can delegate secondary functions to other people and dedicate his/her time to develop issues that have a major impact on the outcome of the projects.

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The Theory of Constraints Application in Resource Leveling Process to Help Construction Management

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Abstract
The construction industry has been changing its managerial process to improve its competitiveness and there are strong demands for new approaches dealing with planning methods. The authors believe the framework propose in this paper will permit an improvement in the scheduling process.The main objective of this paper is to propose an approach to resource levelling process using the concepts of theory of constraints. The results show that the Theory of Constraints (TOC) can be applied to construction industry activities management and TOC can support the development of a new approach for resource levelling. The researchers conducted a bibliographical review to establish the underpin applying the concept of TOC. A case study, in a Brazilian Construction Company, focused the Real Estate market, and demonstrated that in the application of CPM technique one can verify that the constraints analysis must be done before the resource levelling; other conclusion is that the amount of man power per day presents a reduction of 50% when rounding off the resources in the peak day; and we evaluated the cost flow we verified that the theory of constraints application takes to an expenditure of 50% of the cost when we reached 50% of the project duration.

Keywords
Theory of constraints; resource levelling; construction management

INTRODUCTION

When we are thinking about planning elaborating the question that appear in our minds are: where do I begin? Which activity presents the biggest value or urgency? The one that depends on the available resource or the one that opens way to other activity? All of them at the same time?

There are many possibilities, but none seems, logically, the most adjusted. The decisions are taken on the basis of previous experiences, without testing which is the best statistics option. When we decide the activities sequence with technique constraints, the decision is more clear and objective; for example: foundation-> structure -> masonry. But when one approaches activities that can be made in parallel and these activities are opening work fronts to other services, the decisions are based much more on previously learned lessons and personal feeling, than a scientific approach.

When we are elaborating a plan for accomplishment and control of the services we must follow some criteria such as: to be realistic; to be possible, to be executable to take in consideration the limitations (material, man power, place, projects). Or either, any realistic planning must take into consideration the constraints.

Goldratt (1988) defines constraints as anything that has limited system in reaching its best performance in relation to its goal. Assuming an organization how a system where its elements are, in some form (as chain links), dependent between then selves, the Theory of Constraints, normally makes use of a chain in analogy to the organizations in general.

All system must have, at least, one constraint. On the other hand, each system, in the reality, must have a very limited number of constraints. Thus, Ronen & Star (1990) suggest one interactive process with the steps:

a) To identify the bottleneck of the system;

b) To explore the bottleneck;

c) To subordinate everything to the previous decision;

d) To raise the bottleneck of the system;

e) If in a previous step a bottleneck will be surpassed, to come back to the step (a)

Accordingly to the ideas above, the aim of this paper is to consider an approach for resources levelling based on the theory of constraints, in the planning and control in building construction aiming to determine the activities rhythm and production synchronizes.

THE THEORY OF CONSTRAINTS APPLICATION IN THE ELABORATION OF THE PLANS

To analyze the theory of constraints' concepts is verified that for plans elaboration two items are basic. One mentions the balancing of flow, and not capacity, and the other is the most important concept application of this theory as the plans can provide the biggest profit for the company.

The application of these concepts in civil construction makes a reflection about, that way the services can be executed, using the necessary resources, thus he does not exist inventory of finished, half-finished product or raw material. As the product (an apartment for instance) can be placed in the market thus it provides the company a bigger profit, or either, fast seller with delayed investment?

However, in reference to man power, for instance, the situation is different. Therefore the civil construction works presents dependents processes of the man power. This particularity makes with that the teams become one of the main factors to be studied and finish restricting the use of machines and equipment.

Balance of capacity - Analyzes of the situations

Inside of this item three situations must be verified.

The first one happens when the activity predecessor has a higher speed than the successor, or either, the previous activity goes to open some work fronts making appear an interval between the one that was produced and the next activity to be carried through. This implies in the reduction of profit, therefore resources had been invested to accomplishment of the predecessor activity, beyond the one that the finished half product is displayed the damages and as It cannot be processed to delivery does not exist money entered.

Sap- Predecessor activity speed **>** **Sas-** Successor activity speed **(1)**

The second situation happens when predecessor activity is slower than the successor, or either, case the posterior activity begins soon after that the conclusion of the previous one, this team will be stop for a long period waiting work front to give activity sequence. This also implies in the reduction of the profits, therefore the assembly time is considered as unproductive time.

Sap- Predecessor activity speed **<** **Sas-** Successor activity speed **(2)**

The third situation is when the predecessor activity has the same speed than the successor activity. In this case will be necessary to open one service front of the previous activity to begin the next service. In some cases one sends regards to keep a lag between activities, therefore can occur some unexpected will not have stoppages.

Sap- Predecessor activity speed **=** **Sas-** Successor activity speed **(3)**

To apply the first concept "*balancing of capacity*" is necessary, initially, to verify: the batch size; constraints of the system (man power, place, maximum productivity, restriction technique, maximum team); e, the typology of the dependency between these activities.

Defining the activities

According the PMBOK (2000), activity is one work element executed during the course of the project. One activity, normally, has: duration, expected cost and requested raw material necessary to its accomplishment. The activities can be divided in tasks, they are generic term to the work that is not enclosed in the WBS, but potentially it must be beyond the work decomposition for the responsible work person. Also it is the effort level lowest in project.

In the planning to define the activities is necessary to analyze the flow of the production in the inverse direction (of the finished product until the initial services). In the case of building seller happens for apartment, the alterations are carried out by apartment, but teams are placed for apartment or floor depending on the stage of construction.

In all the cases must be had the flow vision from the finished project to previous stages. This is basic to visualize the recesses or the wait that happen in the work flow. In this paper will be suggested, in accordance with the services to build a foundation – pile foundations for unit. But it is basic to verify as the team will be able to put into motion without occurring the man power wait, half-finished or finished product.

Defining the constraints

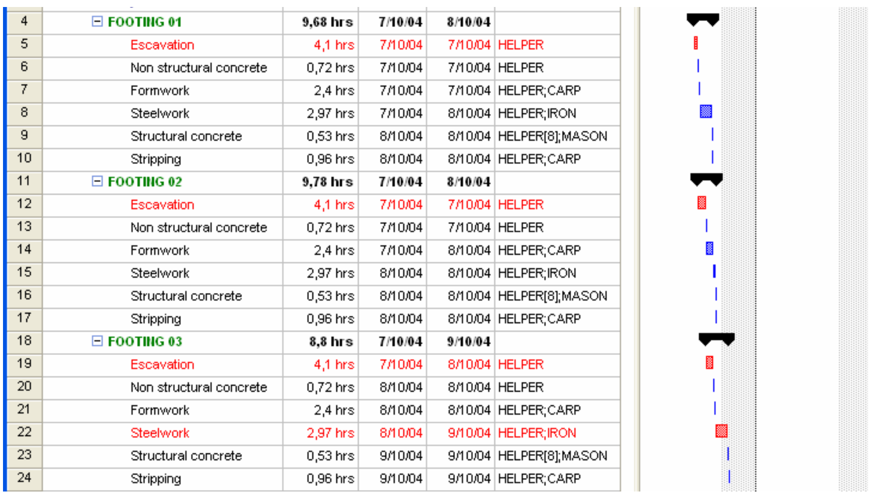
When we are defining the activities we must analyzed the constraints that can occur. We need to point out that in the theory of constraints, the constraints can be physical or not-physics. In this context, both will be identified before the resources levelling, in fact one activity can have one or more constraints and one can suffer interference from another, for example, the place can be limited the team size (SILVA, 1999). To follow some criteria will be detailed and must be considered (KÄHKONEN, 1993):

- Maximum and minimum team - it must be defined maximum team that will be able to carry out this activity, we must considered the maximum productivity and the limitation of space. How much the definition of the team minim must be taken in account the productivity and also be analyzed the minimum number of people necessary to develop the activity;
- Place - the space limitation finishes restricting the size of the team and the sequence of the activity, therefore in exactly local two teams cannot work at the same time;
- Maximum productivity - which the maximum productivity that can be considered in the plans elaboration without that it has supernatural efforts for activity accomplishment;
- Sequence - it can be defined by team constraints or for one technique sequence, for example, the activity of removal of forms cannot be carried out soon after the pouring of concrete, it needs one lag to cure the concrete.

Balancing the flows by attempts

In this paper will be analyzed two situations previously displayed: the first [1] when Spa > Ssa and the second [2] when Sap < Sas. When [1]Sap (Predecessor activity speed) > Sas (Successor activity speed)

Figure 1 – Example of: Spa<Ssa (excavation and non structural concrete) and Spa> Ssa (non structural concrete and formwork) – Initial Flow



4	FOOTING 01	9,68 hrs	7/10/04	8/10/04	
5	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
6	Non structural concrete	0,72 hrs	7/10/04	7/10/04	HELPER
7	Formwork	2,4 hrs	7/10/04	7/10/04	HELPER;CARP
8	Steelwork	2,97 hrs	7/10/04	8/10/04	HELPER;IRON
9	Structural concrete	0,53 hrs	8/10/04	8/10/04	HELPER[8];MASON
10	Stripping	0,96 hrs	8/10/04	8/10/04	HELPER;CARP
11	FOOTING 02	9,78 hrs	7/10/04	8/10/04	
12	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
13	Non structural concrete	0,72 hrs	7/10/04	7/10/04	HELPER
14	Formwork	2,4 hrs	7/10/04	8/10/04	HELPER;CARP
15	Steelwork	2,97 hrs	8/10/04	8/10/04	HELPER;IRON
16	Structural concrete	0,53 hrs	8/10/04	8/10/04	HELPER[8];MASON
17	Stripping	0,96 hrs	8/10/04	8/10/04	HELPER;CARP
18	FOOTING 03	8,8 hrs	7/10/04	9/10/04	
19	Escavation	4,1 hrs	7/10/04	8/10/04	HELPER
20	Non structural concrete	0,72 hrs	8/10/04	8/10/04	HELPER
21	Formwork	2,4 hrs	8/10/04	8/10/04	HELPER;CARP
22	Steelwork	2,97 hrs	8/10/04	9/10/04	HELPER;IRON
23	Structural concrete	0,53 hrs	9/10/04	9/10/04	HELPER[8];MASON
24	Stripping	0,96 hrs	9/10/04	9/10/04	HELPER;CARP

It is verified analyzing the histogram initially gotten from the net assembly (Table 1), that the maximum number of people per day is 14. Another observation is that 50% of the costs are spent in 5º day, or either, when reaching 63% of the project beginning. But the execution time is of 8 days.

Constraints – We cannot increase the hollowing team due the space limitation.

Total duration: exscavation (15x4,1 = 61,5);non structural concrete (15x0,72 = 10,8); so 10,8/61,5 = 5,7 = > 5,7x4,1 = 23,37

Table 1: Man power initial histogram, deadline and cost flow (CPM technique)

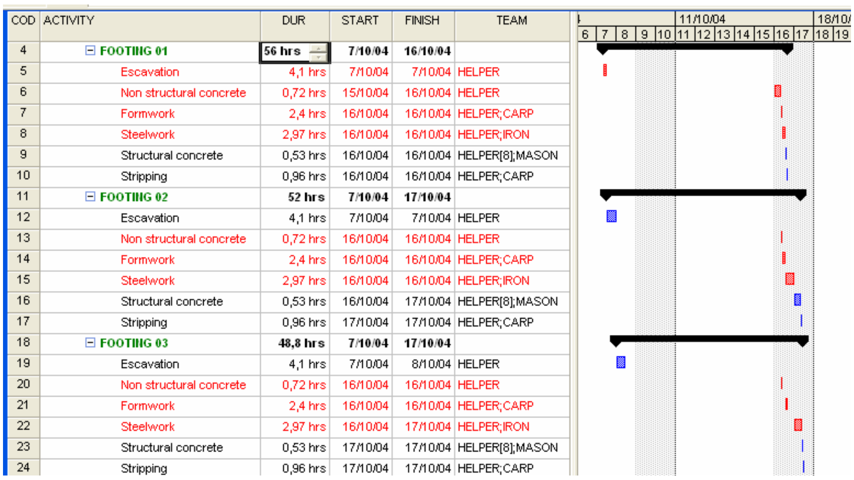
	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a
Date	7/oct	8/oct	9/oct	10/oct	11/oct	12/oct	13/oct	14/oct	15/oct	16/oct	17/oct	18/oct	19/oct	20/oct	21/oct
Helper	3	10	10	10	10	10	10	9							
Carp	1	2	2	2	2	2	2	2							
Ironworker	1	1	1	1	1	1	1	1							
Mason	1	1	1	1	1	1	1	1							
Max/day	6	14	14	14	14	14	14	13							
Value (U$$)	107	548	687	522,9	537,5	547,8	530,6	401,5							
Cumulative Value	107	655	1342	1865	2402	2950	3481	3882	3882	3882	3882	3882	3882	3882	3882
%	3%	17%	35%	48%	62%	76%	90%	100%	100%	100%	100%	100%	100%	100%	100%

[2] Se Sap < Sas- excavation and non structural concrete

This implies that the same time that one excavation is executed 5,7 non structural concrete are executed also, therefore, case the teams initiate to exactly time the team of the non structural concrete will go to wait the team of excavation. To avoid to prevent stoppages, applying the concepts of balance line technique would have to use the equation (4), adding one lag after the beginning of the first excavation.

[T(i total)-T(i+1total)] +t T(i+1) => 61,5-10,8+0,72=51,42

Figure 2– Example of: Spa<Ssa (excavation and non structural concrete) and Spa> Ssa (non structural concrete and formwork) – Balance line technique



COD	ACTIVITY	DUR	START	FINISH	TEAM
4	FOOTING 01	56 hrs	7/10/04	16/10/04	
5	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
6	Non structural concrete	0,72 hrs	15/10/04	16/10/04	HELPER
7	Formwork	2,4 hrs	16/10/04	16/10/04	HELPER;CARP
8	Steelwork	2,97 hrs	16/10/04	16/10/04	HELPER;IRON
9	Structural concrete	0,53 hrs	16/10/04	16/10/04	HELPER[8];MASON
10	Stripping	0,96 hrs	16/10/04	16/10/04	HELPER;CARP
11	FOOTING 02	52 hrs	7/10/04	17/10/04	
12	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
13	Non structural concrete	0,72 hrs	16/10/04	16/10/04	HELPER
14	Formwork	2,4 hrs	16/10/04	16/10/04	HELPER;CARP
15	Steelwork	2,97 hrs	16/10/04	16/10/04	HELPER;IRON
16	Structural concrete	0,53 hrs	16/10/04	17/10/04	HELPER[8];MASON
17	Stripping	0,96 hrs	17/10/04	17/10/04	HELPER;CARP
18	FOOTING 03	48,8 hrs	7/10/04	17/10/04	
19	Escavation	4,1 hrs	7/10/04	8/10/04	HELPER
20	Non structural concrete	0,72 hrs	16/10/04	16/10/04	HELPER
21	Formwork	2,4 hrs	16/10/04	16/10/04	HELPER;CARP
22	Steelwork	2,97 hrs	16/10/04	17/10/04	HELPER;IRON
23	Structural concrete	0,53 hrs	17/10/04	17/10/04	HELPER[8];MASON
24	Stripping	0,96 hrs	17/10/04	17/10/04	HELPER;CARP

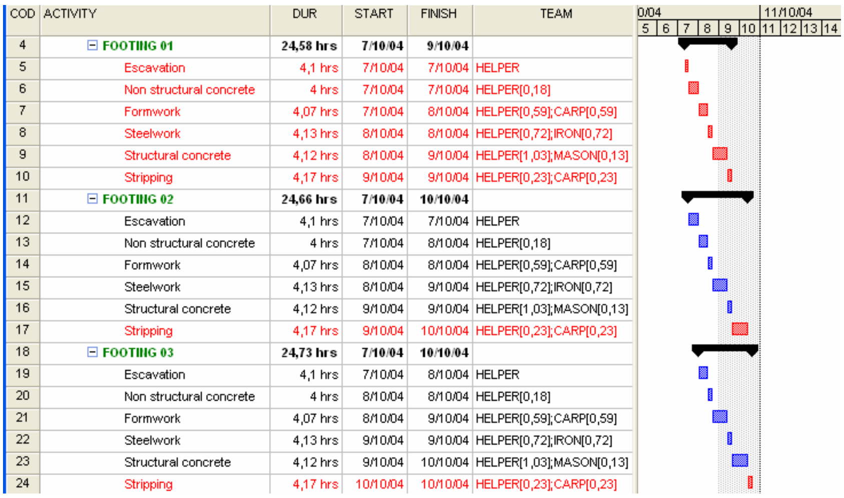
We could verify analyzing the histogram gotten from the balance line technique (Table 2), that the maximum number of people per day is 14. Another observation is 50% of the costs are spent in 12º, or either, when reaching 80% of the project beginning. But the activities execution time is 15 day, almost the double of the previous stated period.

Table 2. Man power histogram and cost flow (balance line technique)

	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a
Date	**7/oct**	**8/oct**	**9/oct**	**10/oct**	**11/oct**	**12/oct**	**13/oct**	**14/oct**	**15/oct**	**16/oct**	**17/oct**	**18/oct**	**19/oct**	**20/oct**	**21/oct**
Helper	1	1	1	1	1	1	1	1	1	10	10	10	10	9	8
Carp										2	2	2	2	2	1
Ironworker										1	1	1	1	1	1
Mason										1	1	1	1	1	1
Max/day	1	1	1	1	1	1	1	1	1	14	14	14	14	13	11
Value (US$)	30,3	36,8	26,8	26,82	26,82	29,85	23,79	0	9,09	664,1	678,8	747,4	722,4	659,7	199,3
Cumulative Value	30,3	67,1	93,9	120,7	147,5	177,4	201,2	201,2	210,2	874,4	1553	2301	3023	3683	3882
%	1%	2%	2%	3%	4%	5%	5%	5%	5%	23%	40%	59%	78%	95%	100%

Accordingly to the theory of constraints concepts this solution does not increase the enterprise profit, therefore the activities are executed in previous time and they wait that the next item begins despite the histogram to present a bigger delayed outlay, the deadline presents greater and the amount of resources is less than the initial flow. In this situation this paper considers to balance the flow to apply the steps following: a) The activities are defined; b) The restrictions are defined; c) the productivity desired for each activity (medium) are defined; d) The maximum team are defined; e) The duration are calculated; f) The sequences are defined (work flow); g) Recalculated the flow considering for each activity the biggest duration of the flow, redefining the size of the teams, but keeping the relation between the indices; h) The evaluation of the best way depends the criteria to be considered. The result can be verified when we analyzed the example below:

Figure 3– Balanced flow after application of the considered steps



COD	ACTIVITY	DUR	START	FINISH	TEAM
4	**FOOTING 01**	**24,58 hrs**	**7/10/04**	**9/10/04**	
5	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
6	Non structural concrete	4 hrs	7/10/04	7/10/04	HELPER[0,18]
7	Formwork	4,07 hrs	7/10/04	8/10/04	HELPER[0,59];CARP[0,59]
8	Steelwork	4,13 hrs	8/10/04	8/10/04	HELPER[0,72];IRON[0,72]
9	Structural concrete	4,12 hrs	8/10/04	9/10/04	HELPER[1,03];MASON[0,13]
10	Stripping	4,17 hrs	9/10/04	9/10/04	HELPER[0,23];CARP[0,23]
11	**FOOTING 02**	**24,66 hrs**	**7/10/04**	**10/10/04**	
12	Escavation	4,1 hrs	7/10/04	7/10/04	HELPER
13	Non structural concrete	4 hrs	7/10/04	8/10/04	HELPER[0,18]
14	Formwork	4,07 hrs	8/10/04	8/10/04	HELPER[0,59];CARP[0,59]
15	Steelwork	4,13 hrs	8/10/04	9/10/04	HELPER[0,72];IRON[0,72]
16	Structural concrete	4,12 hrs	9/10/04	9/10/04	HELPER[1,03];MASON[0,13]
17	Stripping	4,17 hrs	9/10/04	10/10/04	HELPER[0,23];CARP[0,23]
18	**FOOTING 03**	**24,73 hrs**	**7/10/04**	**10/10/04**	
19	Escavation	4,1 hrs	7/10/04	8/10/04	HELPER
20	Non structural concrete	4 hrs	8/10/04	8/10/04	HELPER[0,18]
21	Formwork	4,07 hrs	8/10/04	9/10/04	HELPER[0,59];CARP[0,59]
22	Steelwork	4,13 hrs	9/10/04	9/10/04	HELPER[0,72];IRON[0,72]
23	Structural concrete	4,12 hrs	9/10/04	10/10/04	HELPER[1,03];MASON[0,13]
24	Stripping	4,17 hrs	10/10/04	10/10/04	HELPER[0,23];CARP[0,23]

We could verify analyzing the histogram gotten from the theory of constraints principles (Table 3), that the maximum number of people per day is 5,42, 62% less than others techniques. Another observation is 50% of the costs are spent in 5º, or either, when reaching 50% of the project beginning. Activities execution time is 10 days, or either, 25% greater than the presented one in the first one case and 44% less than second case.

Table 3: Man power histogram cost flow and deadline (Theory of Constraints)

	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a
Date	**7/oct**	**8/oct**	**9/oct**	**10/oct**	**11/oct**	**12/oct**	**13/oct**	**14/oct**	**15/oct**	**16/oct**	**17/oct**	**18/oct**	**19/oct**	**20/oct**	**21/oct**
Helper	1,77	3,52	3,75	3,75	3,75	3,75	3,75	2,75	1,98	0,23					
Carp	0,59	0,59	0,82	0,82	0,82	0,82	0,82	0,82	0,23	0,23					
Ironworker		0,72	0,72	0,72	0,72	0,72	0,72	0,72	0,72						
Mason		0,13	0,13	0,13	0,13	0,13	0,13	0,13	0,13						
Max/day	2,36	4,96	5,42	5,42	5,42	5,42	5,42	4,42	3,06	0,46					
Value (U$$)	44,1	220	562	565,2	565,1	564,6	560,3	511,4	286,6	2,57					
Cumulative Value	44,1	264	826	1392	1957	2521	3081	3593	3879	3882	3882	3882	3882	3882	3882
%	1%	7%	21%	36%	50%	65%	79%	93%	100%	100%	100%	100%	100%	100%	100%

CONCLUSION

This approach is based on the Theory of Constraints (TOC), they were proposed in 1988, by Eliyahu M. Goldratt. However, while his influence cannot be denied and some of his teachings are brilliant, we should remember that Goldratt is not an academic but an entrepreneur. This author enjoyed a tremendously favorable reception because no academic had ever explained theses principles so clearly and succinctly. As for academics, some of them joined in, and the ideas certainly influenced academic teaching and research and production and operations management area (TRIETSCH, 2005).

In this paper we presented how to apply the theory of constraints in the resource levelling making an analysis of the cost flow of the project in the moment that we are elaborating the planning and control by CPM technique.

In the application of CPM technique we can verify that the constraints analysis must be done before the resource levelling, and the application of buffers many times will be necessary and important to prevent that too many tasks be carry out at the same time.

About resource levelling, table 3 presents factionary number of workers, what is not possible in real world. Using the just superior, although inducing worse productivity, is still a good solution.

First we must to compromise the daily activities to define teams into the histogram; second, no matter one rounds the team size (Table 4) the profit is still remained in relation to the previous cases (Table 1 and 2), because there were no wait, half-finished product, and losses in the cost flow. Accordingly to Goldratt (2000), it becomes impossible to use all the resources of the system, thus always will exist working resources, but not in its maximum capacity. Therefore when we are analyzing a system where all activities are working, this would not mean a good performance if all activities are conducting in adequate rhythm, on the opposite, it can be an inefficient system.

It was verified in this work that, applying this theory, the amount of man power per day presents a significant reduction of 50% when rounding off the resources in the peak day.

When evaluating the cost flow we verified that the theory of constraints application presented an expenditure of 50% of the cost when reaching 50% of the project beginning, since in this case the line of balance technique presented an expenditure reaching 50% after 80% of the project beginning while that the initial forecast would reach 50% after 63% of the project beginning. But we have to stand out that the time of activities execution in the first simulation (CPM) was 8 days, in the second simulation (line of balance) was 15 days and in the third simulation (theory of constraints) was 10 days.

Table 4: Man power histogram (Theory of Constraints)

DIA	1a	2a	3a	4a	5a	6a	7a	8a	9a	10a	11a	12a	13a	14a	15a
DATA	7/out	8/out	9/out	10/out	11/out	12/out	13/out	14/out	15/out	16/out	17/out	18/out	19/out	20/out	21/out
SERV	2	4	4	4	4	4	4	4	2	1					
CARP	1	1	1	1	1	1	1	1	1	1					
ARM		1	1	1	1	1	1	1	1						
PED		1	1	1	1	1	1	1	1						
Máximo/dia	3	7	7	7	7	7	7	7	5	2					
Valor (R$)	44,1	220	562	565,2	565,1	564,6	560,3	511,4	286,6	2,57					
Valor Acum. (R$)	44,1	264	826	1392	1957	2521	3081	3593	3879	3882	3882	3882	3882	3882	3882
%	1%	7%	21%	36%	50%	65%	79%	93%	100%	100%	100%	100%	100%	100%	100%

Thus, when evaluating the profit (number of used resources, the defined period of the project and period of outlay) an advantage in the theory of constraints application was perceived. To counterbalance the criticism, through the application to the old CPM technique allied to the theory of constrictions, could be had the opportunity of improvement the planning and controlled. Here, also, the steps had been listed to get the resources levelling and its impact in the project cost flow to simulate executive scenes.

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The Practice of Project Risk Management in Government Projects: a Case Study in São Paulo City.

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Abstract
Risk management has become one of the most important areas in project management due to uncertain conditions or events associated to a variety of risks, which may have a consequent impact on projects' results. Dealing with these issues in public projects requires qualified management because of the great number of factors, which could hinder these types of projects.
A survey to a sample of companies from this segment has shown that although most companies have the interest to invest time and resources on implementing methods and procedures, most of them do not have a structured risk management.
In this sense, this paper seeks to present evidences from those companies, their needs for maintaining quality risk management in a structured and systematic form. The paper presents the main results of the survey conducted in São Paulo city, addressing methods and techniques for risk management associated to project's implementation, seeking to raise the management quality and competitiveness of companies.
The need for a progressive implementation on project management knowledge was recognized, and also the need to be implemented along with other areas of project management, and project management must be submitted to continuous improvement, in order to leverage its results.

Keywords
Government projects, project risk management, infrastructure projects.

INTRODUCTION

Con formato: Numeración y viñetas

According to Pritchard (2001), most of the decisions, including the simplest ones, involve risks. The main role in project management activities is to drive the operations in order to reach or to overcome the expectations of those who decided on the investment, the stakeholders. Risk management is fundamental to accomplish those objectives, not only trying to keep away from bad results caused by some special events or uncertain conditions, but also acting as a guide in order to maximize the positive results.

In this sense, this paper presents the main results of a survey, conducted among some companies oriented to urban infrastructure construction. The objectives were (1) to identify the main risks involved in the project management of public works contractors and (2) to analyze critically how they manage those risks. In addition, this paper sets up recommendations for the risk management process, so as to increase the firms' competitiveness and improve the project management quality as well.

THE URBAN INFRASTRUCTURE CONCEPT

Con formato: Numeración y viñetas

Different authors propose different concepts to urban infrastructure. In this paper the concept used is that presented by Zmitrowicz; Neto (1997) that consider the urban infrastructure as a technical system of equipments and services required to the development of the urban functions, considering either the social, economical or institutional aspects. Under the social aspect, the urban infrastructure seeks to promote appropriate conditions for housing, work, health, education, leisure and safety. In what refers to the economical aspect, the urban infrastructure should support the development of the productive activities, e.g., the production and commercialization of goods and services. And under the institutional aspect, the urban infrastructure should support the necessary ways to the development of the political-administrative activities, including city management.

Under a systemic approach, the urban infrastructure system is composed of different subsystems, each one with a specific objective related to a particular service, since any kind of infrastructure requests a service, since it demands some kind of operation and relationship with the user, in a large or smaller degree. On the other hand, although the objective of the urban infrastructure subsystems is the services rendered, there is always the need of investments in goods or equipments, like buildings, machines, nets of piping or galleries, tunnels, access roads, among other (ZMITROWICZ; GRANDSON, 1997).

PROJECT RISK MANAGEMENT

Con formato: Numeración y viñetas

According to PMBOK (2000), "the projects risks are events or uncertain conditions that, in case they happen, they provoke a positive or negative effect in the project objectives". The risk has a cause and, when it happens, a consequence. Therefore, risk is a relationship among the probability of occurrence of an event **[P]** and its impact on the results **[I]**.

Project risk management, according to PMBOK (2000), is "the systematic process of identification, analysis and responding to project risks. It includes maximizing the probability and the consequences of positive events and minimizing the probability and consequences to adverse events to the project objectives."

Project risk management is directly related to the other areas of knowledge in the project management field, contributing to the improvement of all operational processes.

It is important that project risk management takes place in all phases of the project life cycle, like the starting, planning, development, control, and completion phases.

According to Wideman (1992), "…failure to give proper recognition to risk management on a project can lead to unnecessary and often substantial losses, or even complete project failure."

The project risk varies significantly during the whole project life cycle and between different phases in the life cycle. Therefore, project risk management has to be established as a continuous and integrated function during the whole project life cycle. It is important especially in the planning phases, when risks are identified, analyzed qualitative and quantitatively and appropriate answers are built for the main project risks. It must be taken into account in project scheduling activities, especially in what relates to time and costs plans.

PMBOK (2000) presents six processes for risk management: [i] planning of risk management, [ii] risks identification, [iii] risks qualitative analysis, [iv] risks quantitative analysis, [v] answering to risks planning and [vi], monitoring and controlling risks.

THE PROJECT RISK MANAGEMENT AS A COMPETITIVE DIFFERENTIAL

Con formato: Numeración y viñetas

In a competitive environment, the companies have to be competitive and also have to look for the improvement of their management processes by developing methodologies capable of driving effective project management, capable of achieving better results. To accomplish it, one of the first steps is to identify the maturity level of its project management activities, as well as the performance of each related process, in order to improve or just abolish them.

Organizations must be capable of applying effective project management processes, including those related to risk management. Focusing on the improvement of their performance, the processes must change from corrective to preventive actions, as the main characteristic of the project risk management is that of being ahead of possible problems and their related solutions.

A model to evaluate managerial maturity is that proposed by Fincher and Levin, presented in the Table 1, applicable when the evolution in risk management can be parameterized. Its use allows not only the recognition of the maturity level, but also the actions for the improvement of the project management processes.

According to the project management maturity, a survey was applied in twenty-eight contractors of public works of urban infrastructure in São Paulo city[1]. The survey consisted on an interview, aimed at the recognition of the maturity profile in project management. The intention was also to address recommendations for the building of a reference structure on project risk management. Based on the Fincher and Levin statements, presented on Table 1, it is possible to identify that most of those selected companies did not reach the level 2, yet. About 64% of the sampled companies declared that they do not use project management methods, neither those structured ones nor those supported by policies or standardized procedures, pointing out the level 1 of maturity, the lowest one.

[1] Considered that the universe was composed of 262 companies registered at the General office of Urban Infrastructure of the Municipal district of São Paulo, the accomplished survey presented 90% in Confidence Level and 15% error, from September, 2004 to April, 2005.

According to the project risk management aspects, no methods of risk project management were found in 61% of the companies and only in 7% of them their projects could count on project risk management, structured and supported by policies, procedures, and standardized forms.

Despite those numbers, 57% of the respondents affirmed that, in their opinion, the companies were willing to spend time and money to implement or improve project risk management processes, what demonstrates a potential to the implementation of methods and procedures in project risk management.

Table 1. Model of managerial maturity according to Fincher - Levin

Level	Definition
1 – Initial	A process doesn't exist. The work is accomplished according to the needs. The success of the project depends on individuals. There is not a formal of project management methodology
2 – Repeated	The project employees are trained on project management basic elements and related areas. A methodology exists, and is applied. The reproduction of the process is emphasized, in way to ensure that the result of the work will be repeated.
3 – Defined	All project management tasks are defined and the processes are documented. Practices of project management are collected and used in order to increase the efficiency and effectiveness of the project.
4 – Managed	The project management process is measured and controlled. The difficulties on the project are previewed by the management and the solutions are found before causing great impact on the project.
5 – Optimized	Focus on the perfection and on the final adjustments of the methodology, looking for the maintenance of the rhythm even when technological changes occur. The processes are in the right place and being used appropriately. All the employees are well-trained and carrying out their functions competently.

Source: (Cleland; Ireland 2002)

While Table 2 shows the frequency of occurrence of the project risk factors, in accordance with the survey data, Table 3 presents their impacts on the projects.

The survey showed that three risk factors were considered of high impacts on projects' objectives: lacks of or delays in reception, with 86% of answers, financial uncertainty on the contracting party, with 68% and changes in the scope of the contract, with 72%.

In what relates to the impact, four risk factors are considered as high impact ones: failures in project risk management, with 50% of the responses, lack of financial resources, with 75%, lacks of or delays in reception, with 92% and financial uncertainty of the contracting party, with 86%.

Among all factors, those ones that present a straight relation to the capacity of the companies on supporting financial impacts due to payments for the rendered services must be pointed out: 92%

consider payments lacks or delays, and 75% consider the lack of finance as a high impact factor on the project quality. On relating these factors to their occurrence frequency, they are considered high risk ones, as 50% considered the lack of finance as moderate risk factor and 86% considered payments lacks or delays as high risk ones, they all are considered as high risk ones, demanding adequate treatments and responses.

Table 2. Classification of risk factors and their occurrence frequency, related to projects that didn't reach the planned results.

Item	Risk factors	Low	Medium	High
1	Changes in economical politics	96%		
2	Government's actions and regulatory policies	89%		
3	Deviations in the cash flow (not caused by the lack of or delay on payments)		57%	
4	Failures in cost management		57%	
5	Failures in risk management		72%	
6	Failures in scope management	68%		
7	Failures in schedule		46%	
8	Lack of financial resources		50%	
9	Lacks of or delays on payments			86%
10	Environmental impacts	86%		
11	Social impacts	79%		
12	Financial uncertainty of the contracting party (PMSP)			68%
13	Changes in contract scope			72%
14	Sum of small effects	72%		
15	Exchange variations	100%		
16	Other (specify): 93% of the companies didn't consider other risk factors			

OBSERVATION: The presented data refer to those obtained in the survey presenting the largest frequency on the responses.
SOURCE: Survey accomplished by the author ROCHA (3).
LEGEND: High frequency
Medium frequency
Low frequency

While analyzing altogether the frequency and the impact on risk, as shown in Tables 2 and 3, it's possible to build a qualitative hierarchy of those factors, in order to point out the main risk factors. It is also possible to verify that some factors perceived by the respondents as an average frequency one, are associated with high impact factors; besides, factors perceived as medium impact ones, are associated to high frequency factors. Because of it, they can be seen as representative factors, and should be taken into account on risk analysis.

It is also possible to identify the risk factors recognized as medium frequency and medium impact ones. Although the classification “medium frequency and medium impact” risk, in general, consider the risks as moderate ones, they should be analyzed carefully, once the incidence of several risk factors may enlarge their impacts on the project.

Failures in scope, time, cost, and risk management were pointed out as medium or high occurrence frequency in projects by many respondents, ratifying the trends on failures increasing when no methods or structured procedures are available.

Table 3. Classification of risk factors, according to their impact, related to projects that didn’t reach the planned results.

Item	Risk factors	Low	Medium	High
1	Changes in economical politics	54% ■		
2	Government's actions and regulatory policies	57% ■		
3	Deviations in the cash flow (not caused by the lack of or delay on payments)		43% ■	
4	Failures in cost management		43% ■	
5	Failures in risk management			50% ■
6	Failures in scope management		71% ■	
7	Failures in schedule	57% ■		
8	Lack of financial resources			75% ■
9	Lacks of or delays on payments			92% ■
10	Environmental impacts	86% ■		
11	Social impacts	96% ■		
12	Financial uncertainty of the contracting party (PMSP)			86% ■
13	Changes in contract scope		42% ■	
14	Sum of small effects		57% ■	
15	Exchange variations	93% ■		
16	Other (specify): 93% of the companies didn’t consider other risk factors			

OBSERVATION: The presented data refer to those obtained in the survey presenting the largest frequency on the responses.
SOURCE: Survey accomplished by the author ROCHA (3).
LEGEND: High frequency ■
Medium frequency ■
Low frequency ■

As far as failures in management happen, the risks tend to enlarge, due to both the possibility of their occurrence and to their impact on projects, once the companies are not prepared to manage them. The statement of the occurrence of fails on management ratifies that those companies are still in a low maturity level, pointing out that the implementation of practices on project risk management should happen in a gradual and progressive way and also with other processes like scope, time and cost management, among others.

Therefore, it is important to highlight which techniques and tools should be prior implemented, looking for easiest adjustments on firms and seeking for immediate results.

As most of the searched companies does not apply risk management on all their ongoing projects, the maintenance of systematized and supported practices on project risk management will help to get a competitive differential, that will end up adding value to their projects and reducing negative impacts due to uncertain events, while maximizing the probability of positive events as well.

Not only the existence of a project risk management process is important, but also the way of its accomplishment, that has to be done in a progressive way, fitting it to other related areas. In this sense, three main phases can be identified as described below, as said by the searched firms. These three phases match the levels of Fincher and Levin maturity model: Phase 01 and Phase 02 try to provide a group of practices related to the maturity Level 02 and Phase 03 provides conditions for the company to overcome this level.

- ✓ **Phase 01:** Understanding, training and applying the fundamental elements of project management and project risk management, seeking for the definition of a basic methodology and its application, assuring process reproduction and the work repetitiveness.

Once the typical profile of the searched companies presents low levels in their management maturity, it is necessary that the main management concepts become well known not only by the projects' team but also by the overall organization, before implementing management procedures.

It is hard to imagine a company with no methods to manage scope, time or cost being capable of dealing with project risk management, as a lonely activity, with no links to other project management areas, in an articulate way.

Therefore, the first phase aims at the understanding, the training and the applying the fundamental elements of project management involving, preferentially, all the project management areas such as integration, scope, time, cost, quality, human resources, communications, risks and procurement. Although some areas can be prioritized; neither of them may be forgotten.

- ✓ **Phase 02:** Selecting, developing and applying basic project management and project risk management tools to all management processes and all the ongoing projects.

Once consolidated Phase 01, it is possible to start Phase 02, continuing the implementation of the recommended project risk management practices.

Phase 02 has as main objective the definition of all project management processes, including those related to project risk management, extending its application to all projects phases and their respective life cycle.

- ✓ **Phase 03:** Enlarging project management processes and applying tools and techniques, including project risk management by defining a structured methodology supported by policies and standardized procedures in all projects. It will be necessary to look for gathering information about project management practices in order to increase the efficiency and effectiveness in the project management process itself. It will end up adding competitiveness to the company by anticipating difficulties and risky situations along the project life cycle that will help the implementation of preventive solutions.

In that phase, the main objective is to conclude the implementation of the project management processes with emphasis on previously identified risk factors, analyzing the performance in applying techniques and tools, consolidating a project management methodology, including project risk management.

All the processes of managing risks should be applied aiming as main results both the anticipation of the difficulties and the identification of answers, in order to avoid great impacts on projects objectives.

Finally, a continuous process of improvement should be implemented so as to provide methodology adjustments and suitability, looking for updating on technological changes and company management, seeking for highest levels on managerial competence.

FINAL REMARKS

Con formato: Numeración y viñetas

This paper presented the relevance of project risk management as a process capable to add quality to project implementation, especially in the case of urban infrastructure construction, bringing a competitive differential to contractors of public works, considering that the majority of the searched public works contractors don't apply project risk management methods although the most relevant risk factors have been detected.

The field data were obtained from a survey conducted among public works contractors in São Paulo city, which resulted in a need for structuring and implementing a project risk management methodology, capable of reducing the incidence and the negative consequences caused by adverse events in their projects.

According to the data, the need for a progressive implementation on project management knowledge was recognized, and also the need to be implemented along with other areas of project management, such as scope, time and cost management, once according to the search failures in these processes are recognized as important risks factors.

It's important to point out that in any project management process the continuous improvement should be sought as a way to leverage its results.

In that way, additional researches are recommended, mainly in what refers to the results that will be obtained by the implementation of the improvements such as those suggested here, which will allow new improvements again.

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An Expert System for Scheduling Execution of Massive Housing Projects

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Abstract
Scheduling the execution of a massive housing project is a process that takes into account a great number of factors for decision making. Some of these factors are: geographic distribution of the housing units, existing urban infrastructure, type of unit, availability and experience of the field engineers, provision of the materials program, and availability of the labor, among others. For this work, interviews to expert Managers on these types of projects were required in order to extract the knowledge for handling all these factors simultaneously; in particular those dealing with time pressured scheduling the start-up of several work fronts in the project. This work presents a proposal of a computerized system to facilitate this process to a great extent, by means of the application of intelligent systems. With this system it is possible to offer to these managers, a tool capable of administrate work fronts and to transmit the knowledge of experienced Managers to those that are less experienced. Also, it can be used as an educative package and training package. The system prototype was programmed in Visual Basic©, AutoCAD© and MS Access©, with ECLIPSE© as the intelligent component that bounds all these systems together.

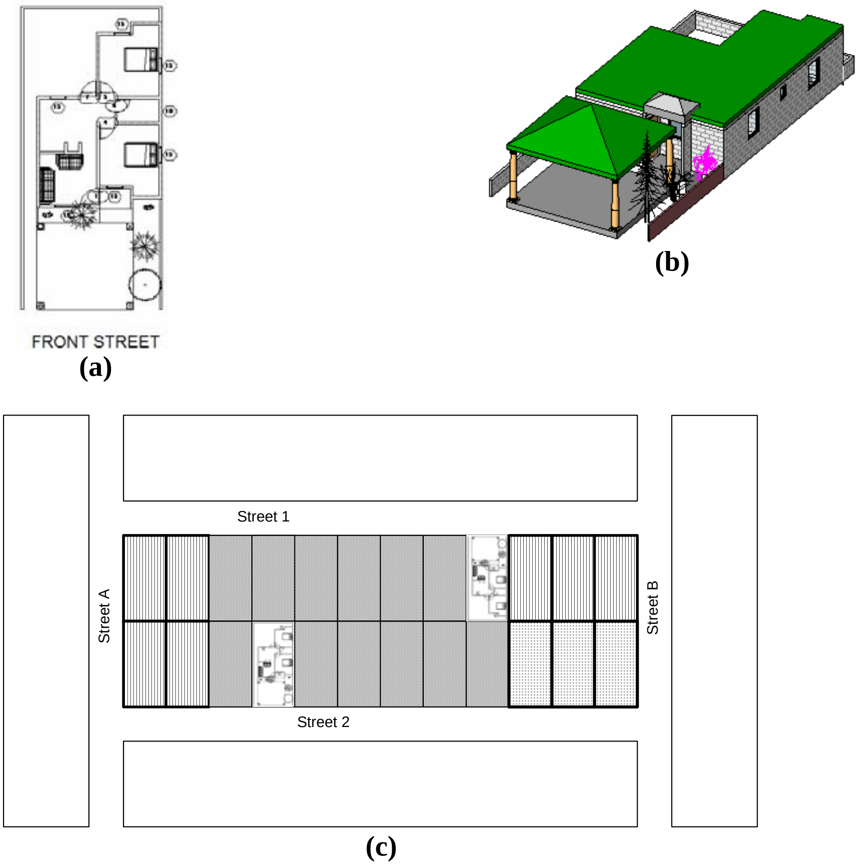
Keywords
Scheduling, intelligent systems, work fronts, housing project.

INTRODUCTION

Housing construction is one of the more important activities in the Mexican construction industry. In this sector, a great number of massively housing construction projects are developed. Unfortunately there is a lack of education about planning on-field execution of this type of project. Usually this is done with very simple methods for planning and control, such the bar chart method, with elementary detail (Pech y Loría, 1998).

Logically, the lack of suitable planning is reflected in a deficient accomplishment of works, excessive consumptions and wastes of resources, irregular productivity and great differences between the planned times and the real ones. The 95,23% of a sample of 25 companies surveyed use the Gant method to make the scheduling of their projects, 50% of these companies use it because of its simplicity, other 50% uses it like just as a requirement to fulfill contractual agreements (Selem, 1999).

Fig. 1



(a) A typical housing unit, with medium level of complexity. (b) A 3D model representation of the model shown in (a). (c) A working front, with three different housing unit packages, represented by the shading of the terrains. Each package may contain different housing unit models. The project may involve several blocks (not shaded for simplicity), but their subdivided into several working fronts, that can start-up at different times.

When planning field operations scheduling (defining stat-up and completion dates of housing units packages), there is an implicit decision making process for the good development project. These decisions have to be consciously analyzed. The lack of material is a one of the causes of work interruptions, originating delays in the construction plans. The lack of materials usually due to delays in its supplying, a bad estimation, or in the worse of the cases, can be liable to a bad planning. A massively housing construction project it implies the construction of a considerable number of housing units. Each unit has a start-up and a delivery date, which has to be planned and usually implies simultaneous construction of unit packages. In this simultaneity is where the complexity of a project resides (Salinas, 1995).

The project first decisions are related to the physical distribution of the housing unit packages. An experienced field engineer has a capacity to supervise adequately from 25 to 50 units, depending on the architectonical project complexity. The field engineers that supervise these projects are faced to architectonical complexity of the housing unit itself, the size of the house. Also, they are limited to their own experience.

All the housing units in this type of construction project have to be “packaged” (divide it by zones), in order to assign specific portions to specific field engineers (Tirado, 1996). Taking into account the capacities of a specific field engineer, the complexity of the units in each package, the physical size of each unit (in square meters of construction), and the distribution of the packages in the entire project field, all these factors have to be taken into account: the distance between construction material and water supplier centers, the location of labor sanitary facilities, surveillance, etc. These factors are the ingredients to decide in how to integrate all the housing unit packages and to whom they are assigned.

Simultaneous housing construction drives to a series of situations that depending on the number of housing units and their construction simultaneity, may become in factors in which the whole project success resides. An individual housing unit require of at least two workers. This number will increase as the project execution develops, for that particular unit. Depending on the construction methods, these workers are contracted on an eventual basis, reason why not always they are available. A probable number of workers have to be estimated and be compared with those that can be obtained for the project. The same phenomena occur with materials. Some of these materials are bought by weight or volume, and their rate of provision is very slow, reason to provide great amounts of these materials represents to initiate their provision with much anticipation, in order to guarantee that when those materials are required, there are available. Unfortunately, most of the time the latest is not possible, manly due to lack of enough space at the site to store them. The housing units in a massively construction project have to have an infrastructure or urbanization. This structure usually overlaps with the construction of the housing units and for that reason the starting up dates of certain areas of the project. This is another factor that has to be taken into account in the starting up of certain zones of the project and how to coordinate the overlap the urbanization activities with those of the construction unit.

In summary to define the date of beginning of a housing unit, it must be taken into account the physical disposition of the unit in relation to the others, the constructive complexity and the size of the unit, who is the possible field engineer responsible for that particular unit, the availability and characteristics of that field resident, the quantification and availability of the labor, to identify and analyze the critical materials from the point of view of speed of provision, and the interaction with the urbanization activities, among others. All these factors must be taken into account as a whole, and not in an individual way, since the decisions are based on factor affecting the behavior of others, which does that the planning of the starting up of construction quite a complex activity, that only experienced enough people can do in a consciously and intuitively way, in the best one of the cases. There is no method or programming technique that takes into account all the mentioned factors that have to be considered to determine the starting up the construction of packages of housing units.

PROPOSED METHOD OF PLANNING.

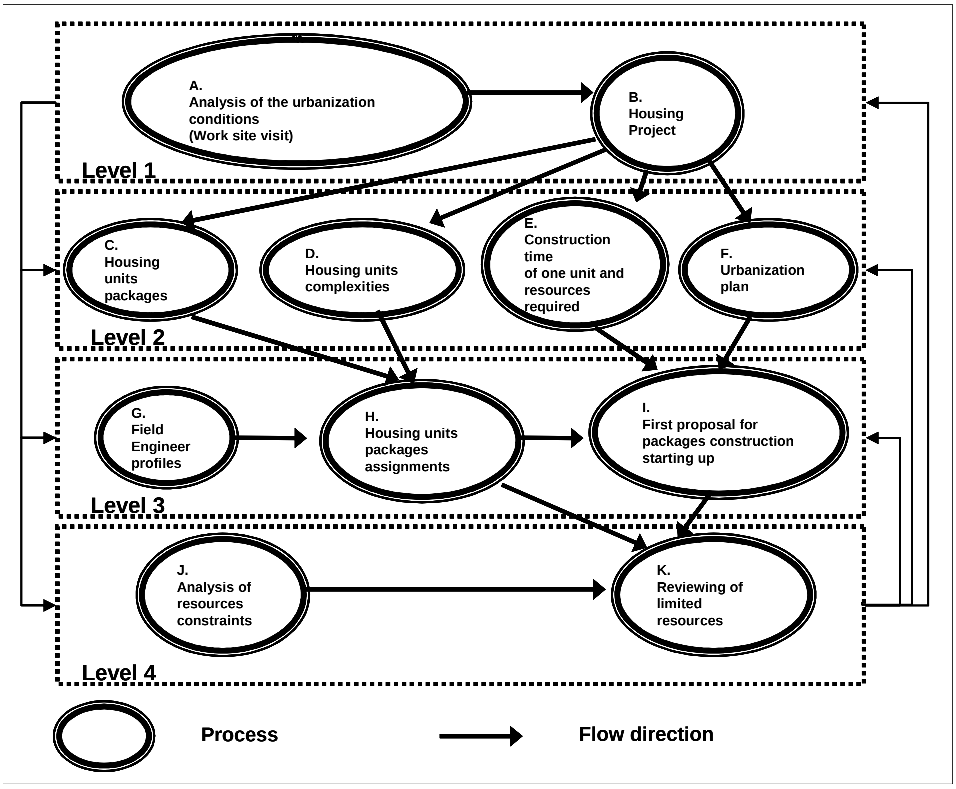
This proposal gives by fact that a housing project (the executive project) is in the definitive phase, and that is counted on this information.

Figure 2 shows the general process of planning of stating-up of construction work planning. Here can be observed the eleven processes were defined, that were produced at the interviews with the experts. Also it is clearly observed that there are four levels or stages, that group and independent processes are defined between them, but that produces resources for processes of the following level.

1. Housing Unit Project .The responsible person to make the housing project will have to integrate in a suitable way the data obtained from the visit to the work site of as well as to take into account the regulations corresponding to the elaboration from a project from house. In this process the amount is decided and the unit models (types of houses) and its physical location in the division of the construction site. Similarly, this person projects the necessary infrastructure (streets, electrification, potable water, pluvial drainage, wells, telephone lines, etc.).

Fig. 2. General diagram for the planning construction starting up of a housing project

General Planning Process for Construction Starting up



2. Elaboration of housing unit packages. This is a process that describes the criteria of how to elaborate packages of housing units (housing packages). The process for elaborating housing packages is a strategy identified from the interviews with the experts. In order to elaborate the housing packages, the following premises hold: "Two or more houses must belong to a same package, if and only if, they belong to the same block, they are of the same model (type) and they are contiguous". The previous thing is a strategy to facilitate the process of allocation of housing units.

3. Complexity of a housing unit. This process refers to obtaining a complexity index for each housing unit. It is important to classify and identify if a house is more complex than another, because the supervision will require more time and care when complexities between the units is higher. On the other hand, when a house type is very simple, both the administrative part as the works supervision will be easier for the field engineer. The architectonic design refers to the distribution and location of the walls on its main axes, as well as the presence of walls not at right angles. The more the number of curved or not at right angle walls, the complexity of a house increases due to more supervision care and time in activities such as tracing, leveling, and walls finishing.

The architectonic details in facades refers to the existence of tilted roofs, arches in windows, circular columns, the use of roofing tiles and domes.

Structural elements refer to the existence of beams, columns, wall reinforcing, door and window lintels, and so on. As more elements of this type a house has, its complexity increases, because the field engineer will have to review more specifications regarding the reinforcement steel specifications, formwork construction, concrete fabrications, pouring, quality, and testing strength within specifications, rebar covering, correct vibrating, curing, etc.

Reinforced concrete slabs deal with their use in small areas, such as in bathrooms, as well with the stairs. These types of elements require more supervision in the steel reinforcement, formwork encasing, pouring, and formwork removing, thus this also increases the complexity of a house model.

4. Field Engineer performance profile. In order to take over the construction of a certain number of housing units, an adequate balance between supervision capacity, management skills, and coordination of task and resources needed and available are required for keeping the field work within cost and schedule. The person who takes responsibility of this work is the field engineer (known also as the resident or field supervisor). It is important that the construction company knows the strengths and weaknesses of each person in this position. It is important to keep an updated performance profile of these persons. In order to determine the individual profiles of field engineers, the construction company has to carry on a historical record of their past performance.

5. Calculating construction time for each house model and requirements for material and resources and labor. One of the challenges of all construction companies nowadays is to carry on profitable projects in a specific time, thus estimating construction time of housing units packages is an important input data for determining the total duration of a project of this type. To this, it also has to be added another factors, such as labor skills and organization, materials supplies, the construction process, the complexity of the unit, the local weather, and so on.

6. Accomplishment of the urbanization plan. Once obtained the drawings of the project, wide and the length of the streets that will have to be constructed, a strategy is defined to determine which streets will have to be constructed first. Additionally, it is necessary to determine the infrastructure for providing potable water, pluvial drainage, wells, etc., for which a working strategy has to be carried out. In this process, it must be taken into account that the work advance in the construction can be interrupted by the use of heavy machinery and explosives, the traffic to vehicular and opened ditches, among others.

7. Assignation of housing units packages to field engineer. For this task, it is necessary to know the following items: (1) When the number of the housing units exceeds the capabilities of the field engineer, the field engineer, the number of houses to be built justifies hiring another one; (2) When the number of housing units to be built is smaller than the field engineer that is assigned to supervise them is able to handle, in a general way it is necessary to determine what extend (in percentage) the engineer capacities are employed.

Once defined the number of field engineers, the allocation of housing packages have to be carried out for taking care of the following aspects: (1) The number of assigned housing units shall not exceed the supervision capacities of the field engineer; (2) The assigned housing units models must be within the models in which the field engineer has experience; (3) The allocation of the field engineers with better performance index must be to the more complex housing unit model; (4) The dispersion between the packages must not be excessive. That is, that the distance between the packages must not be greater to 150 meter. Only in unusual events, these premises cannot be fulfilled and in these cases it is necessary to try following them as far as possible to the recommendations described in this work

8. Working fronts start-up first proposal. The first proposal of fronts start-up is obtained with the information obtained from the field engineers, the housing packages, the urbanization plan profile, the duration of the construction of a housing unit, and resources (by house model) requirement by period.

9. Constrained resources analysis. In order to carry out this process, the use of historical information of the company on previous projects and external information of the material suppliers is required. In the context of massive construction of low income housing units, according to the results of the interviews to the experts, are mainly focused on labor and materials.

Regarding to material resources, the following items were identified as critical: cement and aggregates, concrete blocks, reinforcement steel, floor tiles, and prefabricated parts for roofing construction. Their amount is critical as the suppliers and producers can provide, the physical size storage at the site is, and the rate that they can be supplied.

10. Limited resources for the final start-up proposal. This process consists in reviewing that the totality of the resources meet with the maximum amount obtained from the constrained resource analysis. It is characterized by two main aspects: limited resources requirements and delays between work front starting-up.

EXPERT SYSTEM DEVELOPMENT.

The method herein proposed is the result of the interview wit the experts and the bibliography available for this work, and it became the knowledge base of the expert system (Figure 3). The system has an interface with Autodesk™ AutoCAD© 2000 (Figure 4), for the automatic evaluation of the geographical distribution of the housing units of the project. This expert system was developed with Visual Basic© 6.0 (Figure 5), and Athena CLIPSOCX© (Figure 6). The inference mechanism of this system works in a forward-chained fashion, based on production rules. The system is capable of taking autonomous decisions. However, the user can know and modify the decisions taken by the system. The system offers more flexibility to the user decision making process.

Fig. 3. Expert system general structure

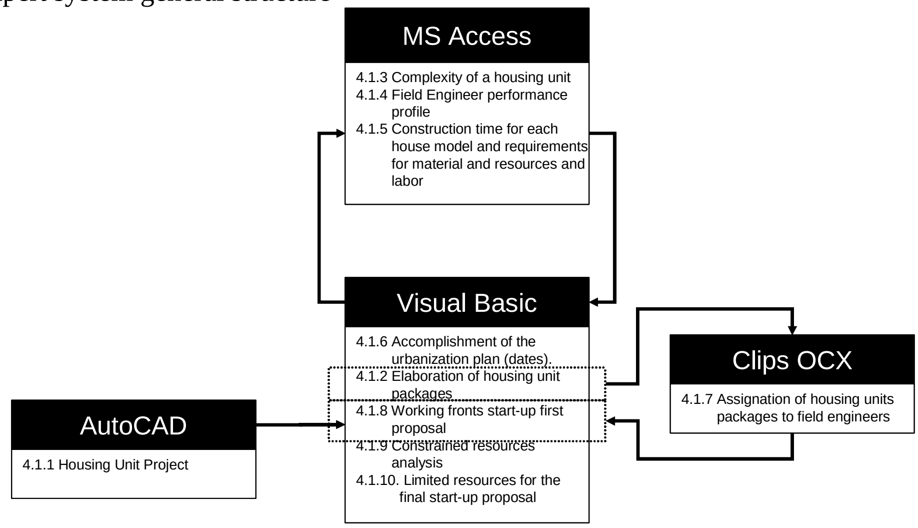


Fig. 4. AutoCAD Input and Output results, with different housing models and work fronts.

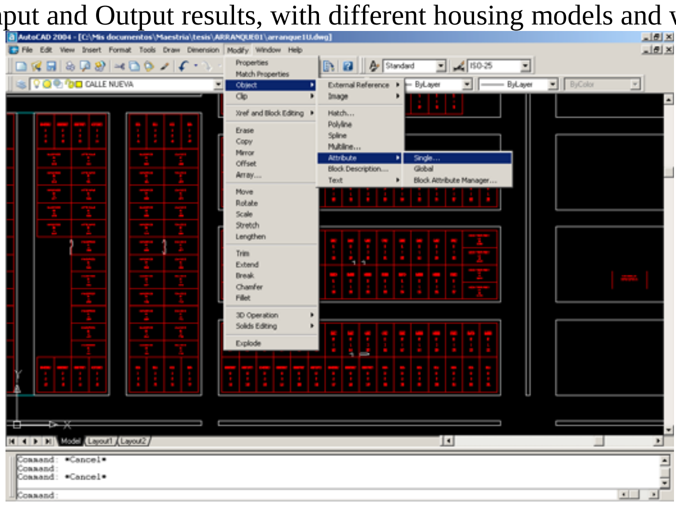


Fig. 5 Access/Visual Basic interface. In this case, the module for assigning resources by period is shown.

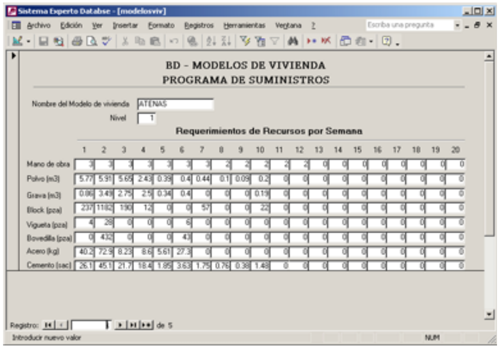
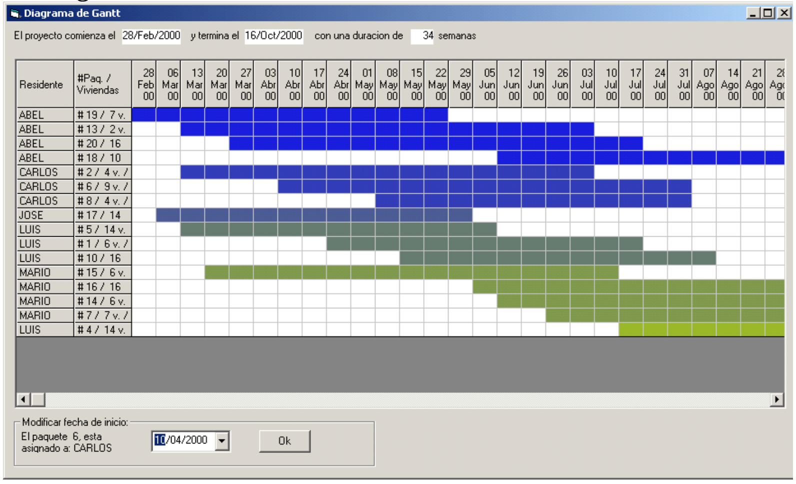


Fig. 6 Access/ClipsOCX interface. In this case, the module the first start-up proposal and assignation to field engineers is shown.



CONCLUSIONS

The method proposed in this work offers a guide to project managers for massive construction of low income housing projects, in order to make work front starting-up strategies more consistent, avoiding many problems that happens in the job execution, reducing inefficiencies, low productivity levels, and unnecessary delays in programmed execution dates.

This expert system is also a source of dissemination of the experience found in the construction practice. This system is offered also as a training tool for the academic community, because it focuses the attention in aspects that are commonly felt by civil engineering students.

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Causes of Fissures in slabs of industrialized construction systems in Colombia

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Abstract
The aim of every construction project is to satisfy the ultimate client, the buyer, within established budgets and schedules. However, the lack of appropriate construction techniques implemented on site or the use of inadequate resources may bring as a consequence, unsatisfied customers.

This article presents the results obtained from a research project done at the Javeriana University, Bogotá (Colombia). Its main purpose was to determine the reason why cracking occurred to the slabs of buildings made with concrete-based industrialized systems, composed of structures using load bearing walls and slabs exclusively. It focused on buildings of more than four floors, done in Bogotá, with metallic formworks such as tunnel and modular hand carrying panels. The project was done in different stages, each one concentrated on specific components of the industrialized systems.

The industrialized systems are being used in diverse countries of Latin America, turning the results of this research, of general interest for people involved in the construction sector in developing countries.

Keywords
Outinord, contech, industrialized construction systems.

INTRODUCTION

The concept of industrialized systems for construction is associated to certain processes that generate increased productivity on site, as well as a better use of the materials. This is done with an adequate planning of the activities and resources, and a sort of "mass production line", similar to those used at factories.

Even though industrialized systems may involve diverse techniques and practices around the world, in this particular case, it will be understood as industrialized systems, the on site construction, based on repetitive processes, with structural systems made of load bearing walls and slabs. Among this concept, four main resources can be found: the formwork, the materials, the equipment, and the labor. This article is limited to housing buildings with reusable formworks. This system is also used in Chile, Brazil, Costa Rica, Mexico, Guatemala, Dominican Republic, Panama and Ecuador, among others.

Projects done with industrialized systems encountered fissures with no specific pattern in the slabs. Hence, it became imperative to find out its possible causes. To achieve this objective, we needed to study the aspects involved in the industrialized construction projects. This was done in four main stages one implying the study of the real construction processes being used, another one studying in detail the characteristics of the concrete. A third stage was defined to analyze the collected data from the previous phases, and finally, a stage of conclusions and recommendations. The definition of the four phases of the project, will allow us to study acutely resources and procedures. It must be stated that when this project was defined, the concrete mixes Outinord and Contech had not been studied in detail, the concrete producers knew they were over designing it but not the exact percentages along time. Similarly, there was lack of knowledge related to the real loads applied at early stages to the walls and slabs, which generated excessive requirements for the concrete mixes and hence, became part of this research.

In other words, the main objectives of the research project were to determine the characteristics of the concrete mixes used in industrialized systems, to establish the constructive procedures employed in the systems, and to define the loads applied at early stages to the structures.

The industrialized systems have not been thoroughly studied and there is no formal document on the topic. However, it is important to state that there are different types of formworks used for these systems, and the most common one is the reusable formwork. This formwork is made of metallic panels, made of aluminum or steel, which behaves as a temporal self load-bearing structure. These panels are enabled to support the loads coming from a constructive process and the pressures from fresh concrete and to mould it according to the architectural design. These formworks have two types used in Colombia: mechanic/hydraulic tunnel formwork and hand carrying panels.

Although the use of metallic formworks represents a high cost, comparing it against wooden-made formworks, which are the most common in developing countries, it becomes cost effective due to the higher productivity associated to the systems.

FIRST PHASE

The first phase consisted in performing a characterization of the constructive processes. To achieve the objective, six construction projects were studied, during 48 hours each. The projects belonged to different construction companies, some of them certified by the ISO standards. The study was made at each construction site, with a follow up of every activity developed during a working week.

As it is known, for building projects using traditional methods, 48 hours do not represent a great progress. However, for projects using industrialized systems, the advance reached in a construction project in a week may represent the concreting of 1.75 levels/floors with its structural walls and slabs, which represents an apartment per day.

With the follow up of the construction projects, some important information was obtained, such as the real construction processes implemented, and the possible unforeseen events involved in this type of projects. In addition, the group found out the velocity in which the slabs and structural walls of the buildings being loaded.

The studies of construction projects were performed during different months of the year, allowing us to perceive different weather conditions. It must be reminded that Colombia is a tropical country, that does not experiment weather seasons, but rainy and dry periods. The city is located at 2.620 m above sea level, with an average temperature of 14°C[1], although it can have a generous gradient of Temperature in less than 24 hours. These particular conditions must also be taken into account for the process employed on site, to care about the concrete mix.

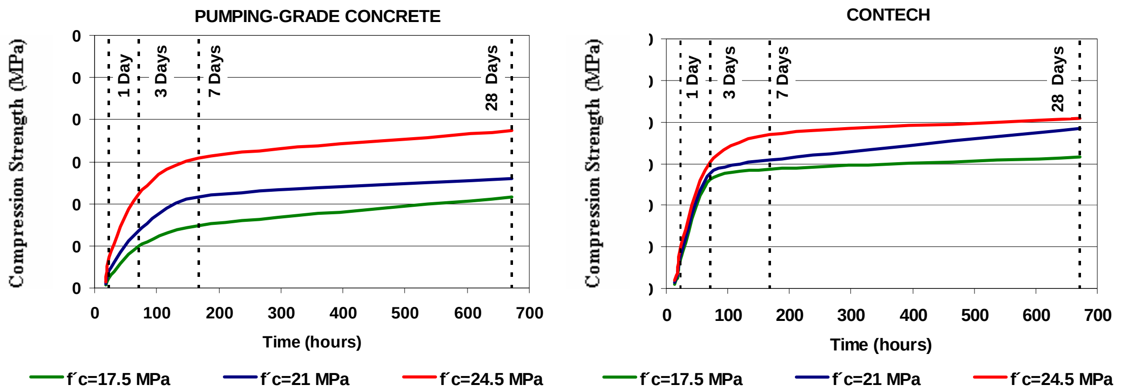
SECOND PHASE

The second phase consisted in the study of the mixes employed for industrialized systems: Contech, outinord as well as a pumping-grade concrete as a reference parameter. The practiced tests were: compression strength, tension strength, elasticity modulus and flexural strength; which were done following the specifications established in the related technical documents (ASTM and NTC). The three strengths studied were 17.5 MPa, 21 MPa and 24.5 MPa at early ages (initial hours and days) and then at 28 days.

The design of the concrete was based on the specifications established by the company Cemex Colombia.

Tests

Following the specifications established in the Norm NTC 673[2], compression tests of concrete samples were carried out at different ages. For the industrialized mixes (Outinord and Contech), the graph presents an accelerated increase of the compressive strength at early ages (between 14 hours and 24 hours). Nevertheless, as of the third day the rate of increase diminishes remarkably, presenting a relatively stable slope. At three days, the strength of the industrialized mixes is greater, in average, than the design strength in a 38%. Additionally, at 28 days the Outinord and the Contech concrete had substantially superior compressive strengths compared to the designed resistance. On the other hand, the pumping-grade concrete did not present an accelerated increase of its resistance at early ages like the described previously, although at 28 days it arrives at values of compressive strength superior to the established initially. These results are shown in the graphs of figure No. 1.



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[1] http://es.wikipedia.org/wiki/Bogotá

[2] ICONTEC, Test for determining the compressive strength of normal concrete cylinders, 2003.

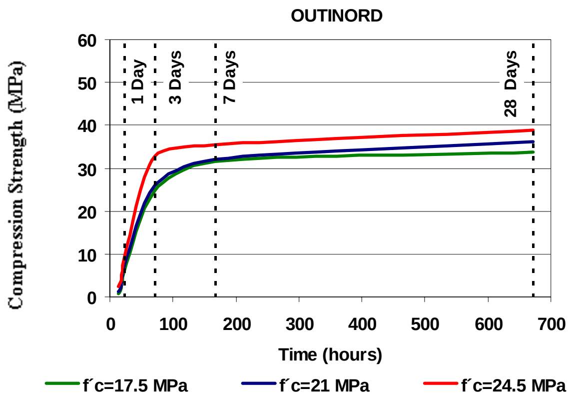

Figure 1. Compression strength of the Contech, Outinord and* pumping-grade concrete *at different ages ([Díaz et al, 2004])

Following the procedure established in the Norm NTC 722[3], tension tests of the studied mixes were carried out. In addition, and according to the Norm NTC 2871 [ICONTEC, 2003], the flexural strength of the concrete mixes (breakage modulus) was determined. The results obtained from the tension strength tests illustrate a behaviour extremely similar to the results obtained for the compressive strength test, an accelerated increase of the resistance until the third day. Afterwards, it shows that the rate of growth of the resistance diminishes remarkably. The pumping-grade concrete at the age of 3 days presented a flexural strength inferior to 2 MPa in all the tested samples. This characteristic shows that the conventional concrete is not appropriate for projects using industrialized systems.

Due to the high velocity of the constructive process, fissures by traction, generated by flexion because of the early application of the loads (weight of the formwork and workers) could appear.

Additionally, the static elasticity modulus for the different concrete mixes studied was determined according to the Norm NTC 4025 [ICONTEC, 2003]. This procedure was used to test the samples at different ages. For the Contech and Outinord concrete, an initial high rate of the modulus of elasticity is observed during the first hours. This growth rate diminishes with the hours but the positive slope of the graphic remains. On the other hand, pumping-grade concrete presents a less pronounced rate of initial growth.

Maturity Method

Although the tests above described were enough to obtain the required characteristics of the concrete mixes, another test was done, considering the temperature of the mixes. The quality of a concrete mix is related to aspects such as the hydration process of the cement materials contained, its water-cement ratio and the admixture quantity. Each type of concrete has a particular and intrinsic quality that is reflected in its thermal profile. By the use of calorimetric studies, it is possible to establish the increase of heat of a cement paste or a concrete mix during the initial hydration process. According to [ASTM, 1998], there is a direct correlation between ΔT_{max} and the evolution of the concrete strength (first 24 hours). It is important to highlight that this method (Maturity Method) is valid only for the concrete mixes used in the industrialized systems because they have a higher resistance at early ages than the pumping-grade concrete. In the maturity method, a small thermally isolated container is filled with a

[3] ICONTEC, Test Method to determine the resistance to indirect tension of concrete cylindrical specimens, 2003.

concrete sample or mortar paste. (Figure 2). Afterwards, a temperature sensor is introduced in the paste in order to measure the temperature and sends this information to the data acquisition system. This test is rarely practiced in Colombia, and it was performed because there is a blatant need of a standardized procedure that allow on site professionals to determine the precise moment of disassembling the formwork.

Figure 2. Calorimeter and assembly for the maturity test

This procedure must be carried out during the first hours of the concrete in order to elaborate a time history of the mix temperature and to establish the calorimetric characteristics of the concrete. This registry of temperature versus time appears for each one of the mixtures studied, in figure 4. Once established the time history of the mix temperature presented previously, it is necessary to determine the relation between ΔTmax and the compressive strength, being ΔTmax the difference between the maximum registered temperature and the initial temperature.

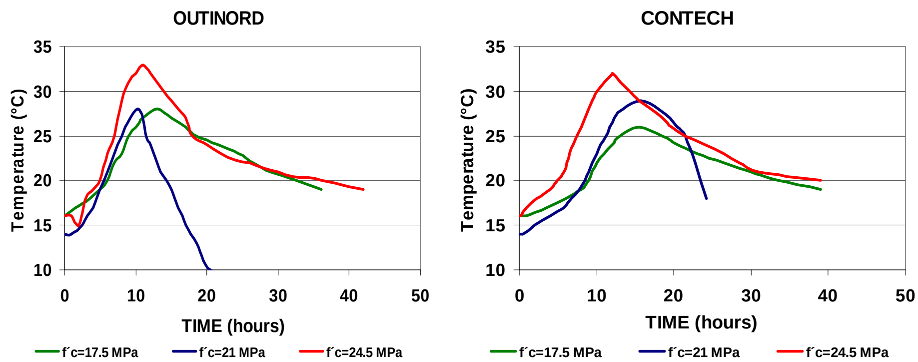

Figure 3. Temperature time history for the industrialized mixes ([Díaz et al, 2004])

With this procedure it is possible to elaborate curves like the presented in figure 4. The curves have a clear linear tendency for the mixes Outinord and Contech (not for pumping-grade concrete). Using these curves the strength of the mix at different ages is established using only registries of the temperature for the first 24 hours.

Considering that one of the most important factors in the concrete mixes for the industrialized systems is the resistance at early ages (days), it is possible to use the calorimetric results of the first 24 hours to estimate the concrete's strength at any day and according to this data to establish the correct moment to disassemble the formwork. Using this type of non-destructive testing, a quality control of the mixes can be made. Additionally, these tests diminish the probability that fissures appear in the plates caused by loads applied at early ages.

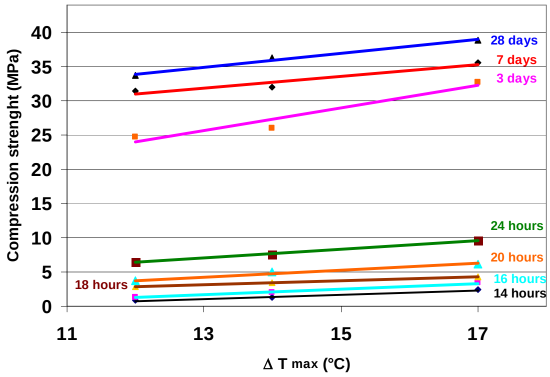

Figure 4. Relation between ΔT max of the calorimetric profile and the compression strength at different ages for the concrete Outinord ([Díaz et al, 2004])

THIRD PHASE: ANALYSIS

During this phase, the group analyzed the results obtained from the first and second phases. Firstly, it was found that the constructive practices used on site differ greatly from the ones expected ([López et al, 2004] [Perilla et al, 2003]). The curing done to the mixes was deficient, as well as the vibrating procedures. The six projects had problems with this two particular activities that recover a major importance in the adequate conservation of the concrete, and the final product delivered (the apartments).

As studied in some final undergraduate projects [Martínez et al, 2004] a curing process done half way brings more problems than benefits. In developing countries the labor is usually based on previous experiences of the workers, there is very few training programs, and most of the construction workers did not finished high school. Frequently, what is done is that workers apply water during a short period of time, then spend time doing other activities, and return to the curing after 5, 6 hours or at the next day. This intermittent curing is extremely ineffective and in cities with high gradients of temperature, it becomes a factor that facilitates the occurrence of fissures in concrete elements.

The first phase also allowed us to determine the pace that industrialized systems use on site. Slabs and structural walls support high live loads three days after its concreting. This occurs because of the concreting of the apartment of the superior level, involving the load of formworks, workers, and tools during the assembly of the formworks, and afterwards the concreting activity itself. This data was important for modeling the structure and finding out the required load that could cause cracking on the slabs.

This phase also included the analysis of a structure built with industrialized systems. Based on the results of the laboratory tests and the characterization of the concrete mixes, a finite element model of a typical critical section of an industrialized building was developed. The typical section of the building was conformed by two load bearing walls and one slab. The span length of the slab was 2,85 meters, as observed during the first phase, and the typical height per level was of 2,3 m. The thickness of the slab and the walls were 10 cm. These values correspond to the typical ones found in the construction projects of up to six floors.

Two analytical models were developed in the program SAP 2000 ® ([CSI, 2000]): a rigorous model with "solid" elements (brick elements of 8 nodes with three degrees of freedom per node) and another model with "shell" elements with 6 degrees of freedom per node (four nodes with three rotations and three displacements). The model with "solids" included the reinforcement of the structural members (steel mesh). This reinforcement was modeled with "frame" elements.

With the purpose of considering the variability of the mechanical properties of the materials and knowing that the formworks' rotation occurs each third day, the elasticity modulus assigned to the material of the walls in the analytical model was 20.000 MPa. This value corresponds to the concrete elastic modulus at the seventh day according to the mechanical tests performed. On the other hand, it was assumed an elasticity modulus of 17.500 MPa for the slab's concrete, which corresponds to the average modulus of the concrete at the third day. According to the cycles of construction, at the third day the workers begin to apply loads to the slabs of the industrialized systems.

The loads applied to the finite element model were the dead load (self weight of the structure) and the live load. In order to standardize the analysis, the live load used in the models was the one specified in the Colombian Code for Earthquake Design and Construction ([AIS, NSR98]): 2 kN/m^2.

In Figure 5, the maximum principal stress in the structural elements loaded with the dead and live load is presented. The values of the tension stresses originated by flexion were between 0.9 and 1.1 MPa and this stresses appear in the upper face of the plate next to the support walls. According to the experimental tests carried out, the average tension strength of the concrete mixes at the third day was 2.6 MPa. Based on this fact, there is a very small probability that fissures appear in the slab when the formwork is disassembled and the slab is loaded with the live load.

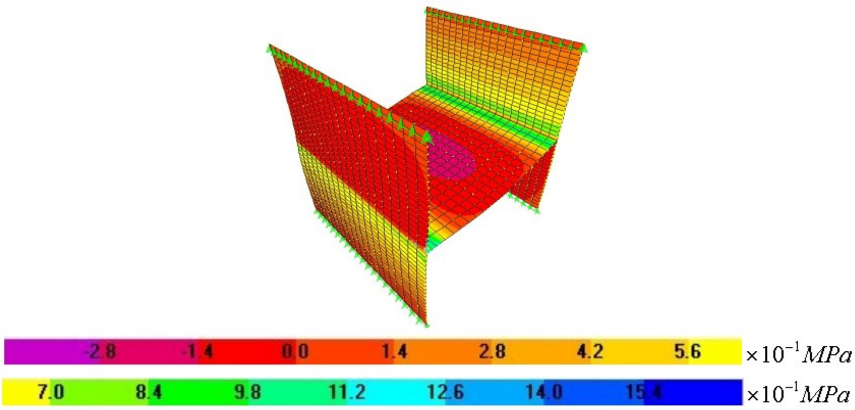

Figure 5. Maximum principal stresses of the structural elements for the load combination dead load + live load

CONCLUSIONS AND RECOMMENDATIONS

The encountered fissures in the slabs of buildings using industrialized systems were not caused by the concrete mix.

The concrete mixes: Outinord and Contech are correctly designed to support the loads at early ages and the live and dead loads established in the Colombian codes.

On the other hand, the construction procedures were insufficient in aspects such as curing and vibrating, were the concrete mixes are experiencing important gradients of temperature, and require external agents to have an adequate behavior.

The fissures found on slabs of industrialized systems might be caused by poorly controlled construction procedures.
At 28 days, the industrialized concrete mixes exceeded the design resistance in 68 and 96%.

The existing conditions of the concrete mixes at 3 days allow the structure to support 2,6 times the applied load.

Finally, the structural designers could reduce the requested concrete characteristics; and the construction supervisors must assure a correct application of the procedures like curing and vibrating in order to prevent the occurrence of fissures.

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Introducing Prefabricated Systems In Home Construction

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Abstract
This paper describes the use of simple and elementary building units, prefabricated concrete domes and joists to create a residential structure adapted to the desert environment and character of the Peruvian north. This paper describes the construction of houses in Piura, Peru using this unique-architectural system. These houses were constructed without the need of skilled labor which is the advantage of the described system. As result of this building experience it was demonstrated that residential structures, esthetically pleasing in appearance, can be achieved at a significant reduction in the cost compared to the customarily used local systems. This system is applicable for use in the provinces where there is a lack of financial capital and only a minimal knowledge of building methods. The system described can be applied directly in many countries which lack a skilled construction labor force and it is very easily adapted to specific environmental conditions. However, acceptance of this construction system requires the allocation of time to train the labor force in order to reduce the risk perceived by contractors to the use of a new building method.

Keywords
Building methods, building systems, construction labor skill, home construction, prefabricated concrete.

INTRODUCTION

The city of Piura, Peru is located approximately 1,050 km north of Lima in a coastal desert. The climate is semitropical, with intense heat during the summer months but with strong winds in the afternoon. Though this is a desert area the area can experience strong seasonal rains, particularly during an El Niño event. The temperature during the summer months averages 24°C, but can reach 40°C even in the shade at certain times during the summer. The warm climate dictates that houses be designed and constructed to guarantee a comfortable environmental for the inhabitants.

Seasonal rains have a direct impact on building design and the El Niño phenomenon, which affects a large portion of Latin America, can be especially strong along the Northern coast of Peru. When the 1983 El Niño rains occurred, the inhabitants of Piura were totally isolated from the world. The Pan-American Highway, the most important route along the Peruvian coast, was cut in multiple locations where it crossed normally dry gorges which had turned into raging rivers (Hadingham, 1987). Observations of El Niño effects have been recorded in Peru since 1525 and the researchers have found geologic evidence of El Niño effects in the communities of the Peruvian coast dating back 13.000

years (Suplee, 1999). Nevertheless, the events of 1983 and 1998 were unusual in magnitude and are recognized as Mega Niños.

Houses in residential zones of Piura are designed following city requirements. However, these guidelines do not consider the occurrence of significant rains that can and do occur in this desert region. The conventional house is designed with a flat concrete roof having little or no slope for diverting rain water. After the extraordinary El Niño events of 1983 and 1998, many houses in this area of Peru required the total replacement of their concrete roofs and ceilings due to the deterioration by corrosion of their reinforcement steel resulting from water ponding for long periods of time on their roofs.

METHODOLOGY

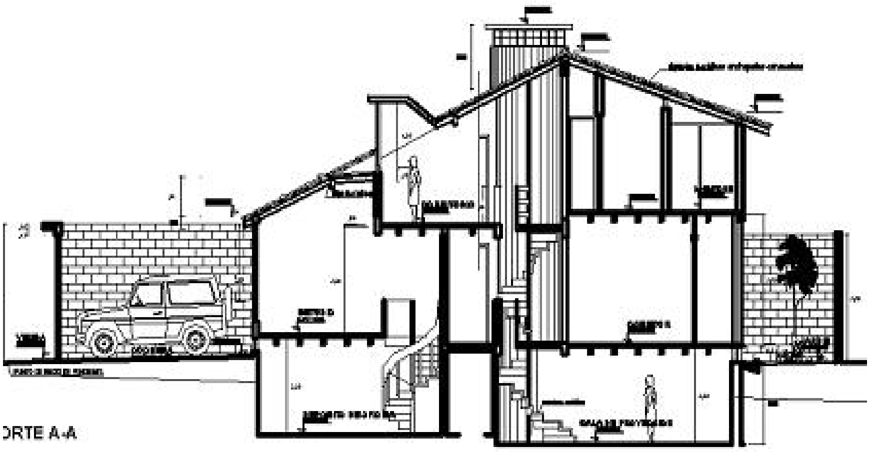
The design, described here, was developed to provide an economical residential structure adapted to the environmental conditions of the northern Peru coastal plane. Although the intent is specifically for houses in the residential zone of a city the design sought to capture the characteristics of traditional rural houses (Figure 1) which were constructed recognizing the importance of air flow in creating a comfortable environment and the occurrence of prolonged periods of rain. The main advantages of the system are:

- Allows ventilation and freshness that is necessary for personal comfort in this climate. The design utilizes interior height of the rooms to accomplish this objective.
- Permits roof drainage by the use of a sloping roof. This drainage characteristic ensures the durability of the roof and the long life of the house.

The use of an atrium, see Figure 2, contributes to the ventilation and illumination of the interior of the house and a sloping roof easily sheds rain water. The atrium extends from the first floor living room in the front of the house to the second floor ceiling of the bedrooms situated in the rear of the house.

Figure 1 Traditional home in northern Perú.

Figure 2 Section view of the house type.



Because Piura is located in a desert region, wood is very expensive compared to concrete. Additionally, the local labor force is not experienced in working with wood as structural elements for buildings. Therefore, while the constructive system maintained the appearance and form of beams and wood joists, for maintenance and security reasons concrete was used as for the structural elements.

THE BUILDING SYSTEM

The system for constructing the floor slabs and the roof, the underside of which is the exposed ceiling for the rooms below, is comprised of prefabricated concrete joists and prefabricated concrete dome panels. Once these are in place a thin slab of concrete is place on their upper side to create a smooth floor slab or roof, and to tie the system together structurally. The exposed under side of the prefabricated dome panels serves as the ceiling of the rooms and there is no need for a final coat of plaster to finish this ceiling. The elimination of the final plaster coat reduces the cost of the house. This simple-concrete-prefabrication system is termed Techo Domozed is being investigate by many researchers (Proyecto Experimental de Vivienda, 2005).

Domes

The dome panels are thin concave elements, 2.5 cm in thickness. These panels are 65 cm by 65 cm square and have a weight of 23 kg (Figure 3). These domes are use in place of bricks which in this local are commonly used to fill the space ceiling joists. The use of concrete domes results in a ceiling/roof structure of less weight. Because the domes also function as a structural component of the ceiling/roof they are cast from a concrete having a strength of $f'c=140\ kg/cm^2$.

The mold for the domes consists of three elements: 1) the support base, 2) the forming frame and 3) the metal frame, Figure 4. The support base (bottom component seen in Figure 4) is constructed of wood pieces 2.5 cm by 3.75 cm (nominal). This is an inverted box which the forming frame overlaps with its fabric resting on the wood of the support base. The forming frame (middle component seen in Figure 4), which is nailed together, is constructed of wood pieces 1.25 cm by 5 cm (nominal). A coarse fabric is stretched tightly over and tacked to the forming frame. In the work described here a polyethylene fabric was used, in many cases however material from old flour sacks is used. The inner dimensions of the forming frame are 65 cm. by 65 cm. The square metal frame (upper component seen in Figure 4) is made of angle iron, 2.5 cm × 2.5 cm × 0.64 cm, and welded together. The metal frame sits with one set of legs up right and the other resting on the wooden edge of the forming frame. The metal frame serves as the mold for the concrete.

Figure 3 Prefabricated 65 cm by 65 cm dome.

The concrete mixture has a cement, sand, and aggregate proportions 2:3:5,. A local natural sand was used together with a crushed aggregate having a maximum size of 1.25 cm. This maximum size of the aggregate is set by the thickness of the dome. The water cement ratio was not controlled. The concrete mixture is place in the metal frame which controls the thickness. Using the vertical legs of the metal frame as a guide the mix is screeded to the proper thickness and then a steel trowel is used to finish the surface.

After the concrete has been formed to the correct thickness the forming frame together with the metal frame containing the concrete is lifted off of the supporting base and placed on a level surface. The fabric on the forming frame stretches under the weight of the concrete creating an upside down dome shaped panel. The forming frame has a height of 5 cm so that is the depth of the inverted dome. It is also necessary at this time as the concrete sags on the fabric to create a uniform border on the edge of the panel (see Figure 3).

After 2 hours of set time the metal frame can be removed. For curing the inverted dome can now be flooded with water for 12 hours, Figure 3. After the 12 hours of curing, the forming frame can be removed but the concrete dome is left in a horizontal position and flooded with water for another 24 hours. Once curing is completed the domes can be placed in a vertical position for storage until they are needed in the project. This can be seen in the rear of Figure 3.

Figure 4 The three components of the mold for the domes.

Joists

The prefabricated concrete joists are 10 cm. wide and 12 cm. in height, Figure 5. With these dimensions the span length is limited to a maximum of 3.5 m. Two labors using ropes can easily handle joists of these dimensions lifting them into place as necessary without the need for mechanical lifting equipment. This handling ability was an important consideration in designing the structural system of the house.

The arrangement of the molds for precasting the joists is very simple. A plastic membrane is spread on a level surface, usually the ground, to form a uniform base and to act as a bond breaker. Then strips of 5 cm × 12 cm (nominal) by 3.9 m in length are used as longitudinal forms, Figure 6. These are spaced 10 cm, clear distance, apart. Small pieces of the same dimensioned lumber and having a length of 10 cm are nailed between the longitudinal forms to maintain the width of the joist and to serve as end blocks. The number of joist cast at one time should be conformed to the capacity of the on site concrete mixer, which is usually a small tilting mixer. The smaller size tilting mixers have a capacity of approximately 0.25 m^3. Therefore, 6 joists are about the maximum that can be cast in one placement. The formwork in Figure 6 shows the formwork and reinforcing steel being set for casting 5 joists.

The reinforcement steel for the joists consists of two #3, A-36 steel, longitudinal bars located in the bottom of the joist. Stirrups of #2 bar are spaced 20 cm apart. In the case of the houses constructed in Piura the stirrups had a G shape. The G had a width of 7 cm, the left side of the G had a height of 16 cm and the right side a return vertical dimension of 10 cm. Therefore, the upper horizontal of the G was approximately 5 cm above the top of the concrete. This projecting part of the G had two purposes: 1) they provide points for easy grasping of the joist during handling and 2) they served to tie the slab which is cast over the joists and domes to the prefabricated joist.

The joist concrete had a design strength of 210 kg/cm^2. The mix proportion was 1 of cement, 2 of sand and 3 of crushed aggregate. A type MS cement distributed by Pacasmayo® Cements was used for the Piura houses. The sand and aggregate used was the same as that for the domes. Again the maximum size of the aggregate was 1.24 cm and the water cement ratio was not controlled. The concrete was consolidated in the mold by roding with a piece of reinforcing bar. Curing was accomplished by means of an earth dike, along the perimeter of the 5 joists, into which water was place each day. This curing was maintained for 14 days. After the curing period the joist can be removed from the forms and stored on level ground next to one another.

Figure 5 Section view of the dome and joist structural system.

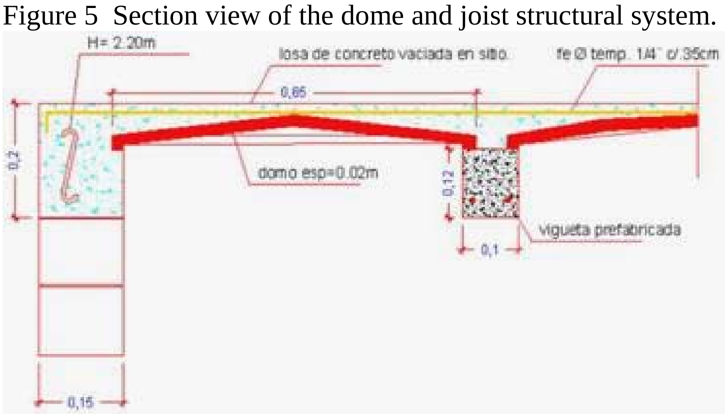


Figure 6 Joist precasting arrangement.

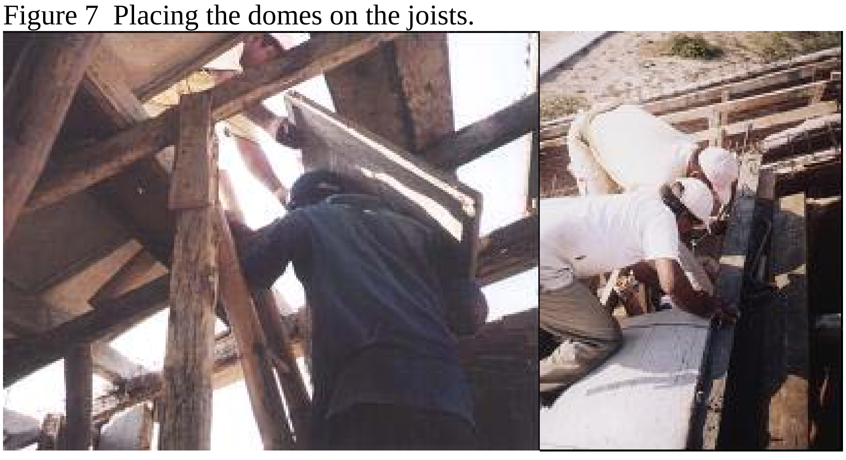
PUTTING THE PIECES TOGETHER

Because the beams, upon which the joists rest, are cast monolithically with the in situ concrete covering the dome and joist system, it is necessary construct a temporary shoring system to support the joist during floor/roof construction. Eucalyptus trees were used as shoring posts for this forming system. These posts were approximately 10 cm in diameter. The posts supported 12.0 by 7.5 cm boards placed vertically. This post and board system was arranged on a 1.2 m center to center spacing perpendicular to the joists and on a 90 cm center to center spacing between posts along the length of the boards, Figure 7.

Once this shoring system was in place the joists could be positioned and then the domes set on the adjoining joists. The prefabricated joists were lift into position by means of ropes attached to the stirrups. Three labors easily handled this lifting task because the joist length had been limited to 3.5 m. Once the joists were lifted, they were positioned on the building walls or the beam formwork at the required 69 cm center to center spacing, which conforms to the dimensions of the domes.

The light weigh domes can easily be carried by a single labor. Labors used ladders to pass the domes from the storage area to the labors positioned on the erected joists.

Figure 7 Placing the domes on the joists.



Before casting the in situ slab over the domes and joist, reinforcing steel was placed perpendicular to the joists. These were smooth #2 bars spaced 32.5 cm on centers, see Figure 5. This reinforcing was primarily for the purpose of controlling temperature effects. Additionally, at the ends and longitudinally along the joist L shaped #3 bars are placed in the upper part of the slab. These bars are 80 cm in length by 15 cm. The short dimension of these bars projects into the beam at the end of the joist that is cast concurrent with the slab. The final step before casting the slab is the placement of the building utility systems (electric, communication) over the domes and joists.

The concrete for the in situ slab had the same characteristics as that used for casting the joists, f'c=210 kg/cm^2. This concrete was also manufactured on site with a small tilting mixer. Again, consolidation was accomplished by roding with a piece of reinforcing bar. A small earthen dike was created along the perimeter of the slab so that water could be ponded for curing purposes. This ponding curing was maintained for 7 days.

RESULTS

The house that was constructed in Piura can be seen in Figure 8. The exterior appearance of the house matches the traditional homes of the region, Figure 1. The interior appearance follows the pattern of rural houses with wood beams.

The interior environmental supports effective acoustics, ventilation and illumination. The atrium space, the living room, in the front part of the house together with the large windows in the ceiling over the second floor sleeping areas facilitates the flow of air through the house. The large upper windows together with the atrium also provide illumination through out the living spaces of the house while at the same time promoting privacy from the outside.

Figure 8 The complete house, compare to Figure 1.

The manufacture of the domes does not require a skilled labor force. An unskilled laborer can be trained in the dome manufacturing process in about one week's time. At the beginning, when the labor force is being trained it is possible to manufacture about 6 domes per day. However, by the end of the week the labors should be completing 12 domes daily. This production rate is for one labor. That labor can accomplish all of the necessary tasks from the preparation of the concrete mix to final curing and storage. The cost of dome manufacturing on the project in Piura was approximately \$1.10 each. Of this amount \$0.62 (57%) was for materials and \$0.48 (43%) for labor. The cost of positioning the domes on the joists is practically the same as that for a conventional brick ceiling.

There is the saving of not having to plaster the domes as would be necessary if a brick ceiling had been constructed. This gives a competitive advantage to the employment of domes as compared to the more common construction approaches.

COMPARISONS

Standard hollow clay bricks in Peru are 30 by 40 cm. Those manufactured industrially have a weight of 8 kg and a cost of $0.32 per unit. Bricks manufactured by hand can also purchased locally. These have a weight of 15 kg and a cost of $0.17 per unit. When the domes are used to create the ceiling the amount of concrete required to cast the in situ slab is slightly greated on a square meter basis than that which is required when bricks are used.

Based on the cost of materials and labor in the Peruvian north the square meter cost of the system with domes, joists, and the in situ slab is $7.54. If hand manufactured bricks are used the total square meter cost is $11.88 and if industrial bricks are used the square meter cost is $13.09. Most of the savings results from the elimination of the need to plasted the concrete domes as compared to what is needed if bricks are used. Not included in this saving calculation is the fact that the shoring required for the domes system is less extensive than that required when a brick ceiling is constructed.

The square meter weight of the finished dome, joist, in situ slab (the Techo Domozed system) with a 20 cm total thickness from base of joist to top of slab is 223 kg. If a hand manufactured brick system is used the weight is 335 kg/m^2 and for an industrial brick system the weight is 277 kg/m^2. This reduction in the weight by the dome system permits the use of less reinforcing steel which is another saving.

CONCLUSIONS

The concrete Techo Domozed construction system permitted the development of a rural-traditional structure with the appearance of a wooden beam and joist structure. The architectural concept as developed matched the environment in which the house was located–a semitropical desert climate. The system is economically competitive compared to the conventional construction processes used in the area. The reduction in the weight is also an advantageous factor, since it allows the use of joist of greater length. This permits greater open space in the structure.

Finally, ability to use local-unskilled-manual labor to produce the domes and joists adds to the flexibility of employing this system and does not harm the quality of the components. Its implementation does however require a time investment in training the work force and close supervision during the placement of the domes on the joists before placing the final floor/roof concrete.

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Industrialising the Construction Industry in Developing Countries: R&D of Strategies & Technologies

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Abstract
The developing countries have the opportunity to do better: whereas in most developed countries the construction industry is still mainly an expensive SERVICE offered by discontinuous gatherings of professionals / businesspeople / craftspeople, the developing countries should avoid that mistake and rather fully apply the strategies and technologies of industrialisation. The strategies: aggregating the market to assure the "quantity" of demand large enough to support a global organisation offering a FINISHED & INDIVIDUALISED PRODUCT. The technologies: amortizing with a large "quantity" the investment in a process capable of simplifying the production and thereby reducing the costs. In the building industry, the product is most likely a building system: a set of parts and accompanying rules where the details are solved before actual buildings are planned. In the case of a developing country, a review of the options indicates three types of appropriate systems:

- Kits of parts, where a few simple factory-made components produced in large quantity can easily be assembled on the site and generate a diversity of building forms;
- Small scale local "plants" organised and tooled to produce all the components near the site;
- Hybrid solutions where the complex parts of a building are factory made and the basic shell built locally using local resources.

Keywords
Industrialisation, strategies, technology, building systems, individualisation

THE NATURE OF INDUSTRIALISATION

Whatever the context and whatever the purpose, industrialisation is presently the only way to reduce cost and improve quality in order to make available to the vast majority of people almost all the products offered on the market, including most construction materials and components (trusses, pre-stressed slabs, curtain walls, etc.). But, generally, it is not the case for the building as en entity.

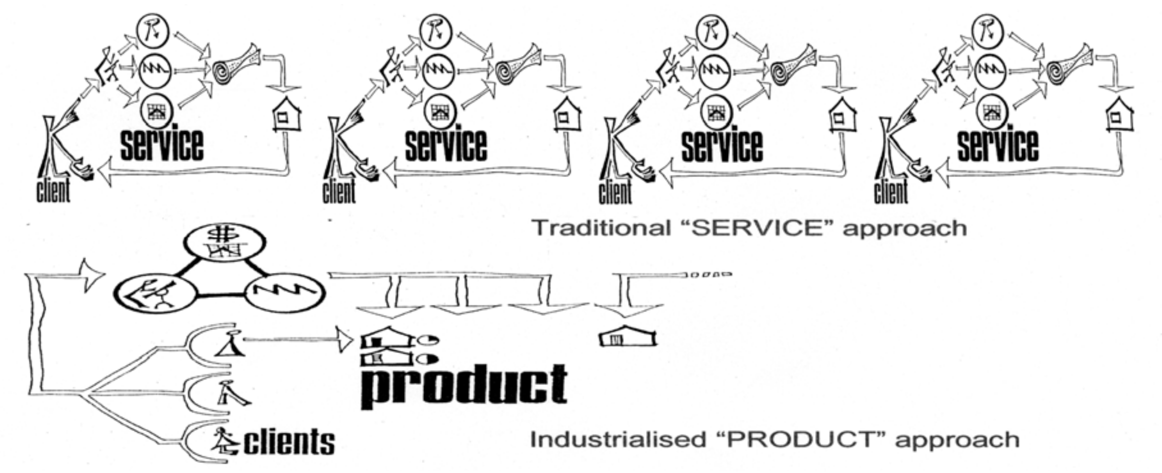
Basically, industrialisation the result of a global organisation based on quantity and offering a finished & individualised product [Richard, 2004.05].

Global organisation

In the traditional approach, construction is a SERVICE offered to a single Client for a single building: a new team of professionals / business people / contractors / sub-contractors / craftspeople is set up almost every time a building gets built and very often the members of one team are members of other teams for other buildings more or less at the same time. As the client initiates and finances the organisation, there is basically no risk for the participants.

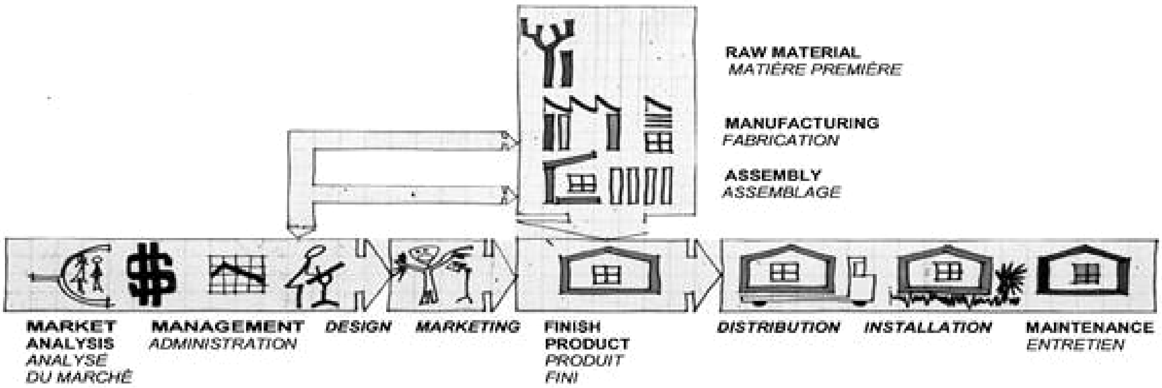
In the industrialised approach to construction, a large market will be aggregated ("quantity") in order to support a "global organisation" of all the participants involved in the continuous delivery of a PRODUCT. To reduce the financial risk at the outset, a market analysis and a feasibility study are usual prerequisites.

Fig. 1 The traditional redundant "SERVICE" approach VS the industrialised "PRODUCT" approach.



A "global organisation" does not imply that all the participants are working for the same large corporation. The model of the big "vertical" corporation that controls everything from the supply of raw material to the distribution facilities is a thing of the past. Most large corporations now operate as "mixed" structures, generally managing the design and the final assembly while sub-contracting most of the production and entrusting the sales to franchised local distributors. Some are completely "horizontal", concentrating on the management and relying on sub-contractors for all activities: the capital investment in organisation and machinery can then be as low as 10% to 20% of the total resources involved, since these sub-contractors have partly amortised their investment over other contracts.

Fig. 1 Global organisation of all the participants in the production of a modular housing system



Quantity (aggregating a large market)

Industrialisation is first and foremost a mathematical equation: a large market ("quantity") will justify a global organisation and amortise (divide into fractions) the initial investment in a process capable of simplifying the production, thereby reducing the efforts i.e. the cost [Richard, 2004.09].

Finished + individualised product

A « finished » product means showing what the clients are going to get beforehand and even permitting them to try it out, as it is the case with the "test drive" in the automobile industry; instead of financially committing the clients on the basis of "preliminary drawings" which are difficult to understand for most of them, as it is the case in the traditional craftsmanship "Service" approach.

In an industrialised building industry, the products are not buildings but mainly Building Systems. A Building System is a set of parts and accompanying rules where the details are solved before actual buildings are planned [Richard, 2004.05]: therefore, construction is not re-invented each time a building is designed, as is still the case with the typical set of "working drawings" in the traditional "Service" approach.

To generate individualisation within mass production, the Building Systems can turn to the same four strategies applied by the other industries: Flexibility of the product, Flexibility of the tools, Multipurpose and Combinability [Richard, 2004.01]. The additional activities related to these strategies are marginal when compared to the aggregation of an even larger market which will further contribute to amortise the process.

PREVIOUS EFFORTS

In the second half of the Twentieth Century, several efforts to industrialise the delivery of housing have been more or less successful: Large scale complexes in post World War II Western Europe, North-American wood-framed factory-made 3D modules, Russian 3D modules in concrete, Habitat 67, Operation Breakthrough's Descon System, Japanese factory-made modules, Off-the-shelf post & beam framework, Automation in Sweden and Hong Kong + Singapore incentives (Fig. 3).

Only the Japanese factory-made modules completely meet the definition of industrialisation; they fully match the organisational structure illustrated in Figure 2. Coming close are the Wood-famed North-American 3D modules and the wood-framed panels produced by Automation in Sweden.

In reaction to the "chicken cages" post World War II complexes, a group of Dutch architects (S.A.R. - Stichting Architecten Research) proposed a methodology based on the distinction between a modular "Support Structure" (structure and services) provided by / for the collectivity and the "Detachable Units" (partitions, equipments and facades) left to the decisions of the occupants [Habraken, 1976]. The methodology is now pursued by the "Open Building Implementation" Group of the CIB [Kendall and Teicher, 2000] and is still influencing contemporary projects, including the recent "Next21" building in Osaka designed under the leadership of Professor Yositika Utida [Utida, 2002].

Unfortunately, some promising proposals did not benefit from either the continuity and/or quantity to really demonstrate their potentials: Habitat 67, Descon and the Off-the-self post & beam kits. Descon is a clear illustration of the "horizontal" organisation mentioned above: "*D/C has no manufacturing facilities for off-site production. All elements of the system are produced in existing local plants, as in the case of pre-stressed concrete, or in regional plants as in the case of bathrooms, kitchens, etc.*" [HUD, 1973]. The off-the-shelf post & beam kits offered adaptability, quality and low cost; but they stayed at the prototype level, the most impressive cases being the T.E.S.T. system developed by Helmut Schulitz in California and the GenterStrasse project in Munich by Otto Steidle.

Previous efforts to industrialise the building industry	GLOBAL ORGANISATION	QUANTITY	FINISHED PRODUCT	INDIVIDUALISED PRODUCT	TECHNOLOGY
Large Scale Complexes in Post World War II Western Europe	**Different governmental projects: limited continuity.**	**Very large scale projects.**	**Standardized regimental medium to high-rise multifamily buildings ("Chicken cages")**	**NO. In reaction, the SAR methodology: "Support Structure" by the collectivity and "Detachable Units" by the users.**	**Standardized pre-cast concrete panels for the structure & envelope; elaborate "wet" site assembly.**
N.-American Wood-Framed Factory-Made 3D Module	**YES. Completely factory-made 3D modules.**	**YES. Minimum of 300 to 400 houses / year for the average manufacturer.**	**"Sectional" two-module house, townhouses and multifamily low-rise buildings.**	**YES. Selective variations of usually very traditional models.**	**Prefabrication and automation at the plant; simple in situ connections.**
Russian 3D modules in concrete	**Governmental projects. Completely factory-made 3D modules**	**YES.**	**Repetitive regimental multifamily buildings ("Chicken cages").**	**NO.**	**Factory assembly of thin pre-cast concrete shell; simple in situ connections.**
Habitat 67	**NO, single project**	**354 3D modules,**	**12 story agglomeration of same size boxes prefabricated near the site.**	**Reaction to the "Chicken cages" by articulating boxes as distinctive geometrical units.**	**Pre-cast concrete boxes connected through a complex post-tensioned network.**
Operation Breakthrough: Descon System	**YES, subcontracting to local + regional manufacturers.**	**NO, promised, but not delivered.**	**Design-Built multifamily prototypes in Newark and St-Louis.**	**NO.**	**Open system: performance criteria, modular coordination and interfacing rules; pre-cast concrete structure**
Japanese factory - made modules	**YES, at all the organisational, production and distribution levels.**	**YES, 5 000 to 10 000 housing units per year.**	**YES, each house combining ± 10 to 15 small factory-made modules.**	**YES, the client can select options or sketch on a digital table.**	**Modules framed at the edges produced on an automated assembly line.**
Off-the-shelf Post & Beam Framework	**NO.**	**YES: Standard off-the-shelf components.**	**Prototypical building.**	**YES.**	**Post & Beam skeleton with optional infill slabs and envelope panels.**
Automation in Sweden	**Different projects but continuity for the manufacturer.**	**YES.**	**Panel system.**	**Selective variations.**	**Wood-framed panels produced in automated factories**
Hong Kong + Singapore incentives	**Different governmental projects, different contractors.**	**Large scale projects.**	**Standard models.**	**NO.**	**Industrialised technology mandatory in H.K., additional points in Singapore.**

Fig. 3 Chart of the previous efforts to industrialise the building industry

RELUCTANCE OF THE BUILDING INDUSTRY

If industrialised building systems were as limited as mentioned in industrialised countries, it is largely due to the reluctance of the building industry itself. Two main reasons can explain it: fear of change and non-informed professionals.

Fear of Change: the contractors and sub-contractors are not about to modify their way of doing business as they are comfortable and experienced with it, the developers do not want to add a technical risk even if the economical advantages are obvious "on paper" and the architects are afraid of losing some "freedom of creativity" or a part of their fees as the details of a system are by definition solved at the outset by others (i.e. the system initiator or sponsoring organisation)

Non-Informed Professionals: according to Abraham Warzawski, a major lack of education regarding industrialisation is the main reason for the reluctance of the construction industry. *"Paradoxically, the last factor – lack of sufficient acquaintance with industrialization among building professionals – has always provided, and still does, the greatest impediment to its successful application in practice"* [Warzawski, 1999].

BACKLASH

In most highly developed countries, like the United States of America, there is presently a backlash against the traditional craftsmanship Service approach in favour of an industrialised process & product approach. "*We need a new vision of process, not just product…The world, and our clients, have seen what has been accomplished in other manufacturing fields : ships, airplanes and cars. Higher quality and added scope and features are there, along with lower cost and shorter time to fabricate. The old equilibrium between cost and time no longer holds. The mandate for change has now shifted to architecture. We cannot continue to build architecture at ever higher costs, longer schedules, and lower quality. We must act"* [Kieran and Timberlake, 2004].

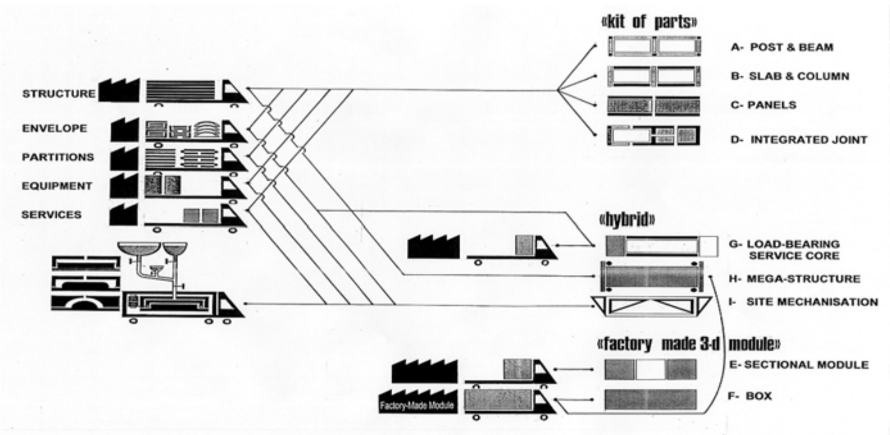
THE OPTIONS

As an industrial product normally comes out of the factory completely finished, the same is expected with buildings. "*The ultimate goal of prefabrication technology is to transport a finished product to the site*" [Utida, 2002]. Factory production (prefabrication), by itself an advantage over on site construction, offers climatic protection, justifies the investment in sophisticated production tools, permits a rationalised distribution of the work on an assembly line which simplifies the operations thereby allowing for the use of semi-skilled labour, assures the conditions for a better quality control, provides a single delivery point for bulk purchasing and eliminates the usual construction wastes.

But as buildings are site-related and technology is normally factory-related, the relationship to a site is still an important factor in the generation of a building system. According to that relationship, three families of Building Systems can be outlined: the site intensive Kit-of-Parts; the Factory-made Module and the Hybrid.

In a sense, they are the basic three colours (i.e. blue/red/yellow) from which the 9 building systems types [Richard, 2004.01] are generated: from "A" to "I". The main functions of the building generate the sub-systems: Structure, Envelope, Partitions, Equipment and Services.

Fig. 3 Distribution of the work between the factory and the site



The four types of systems within the site intensive KIT-OF-PARTS ("Meccano") family are distinguished by the geometry of the structural sub-system which determines the jointing to do at the site. In each case, the components are easy to produce and many developing countries already have the plants to run them.

Table 1. The four types of site intensive Kits of Parts

I- SITE INTENSIVE KIT OF PARTS ("Meccano"): • All sub-systems made at specialised plants • Transported to the site separately • Important jointing operations on site	A- POST & BEAM: Skeleton open to horizontal & vertical infill; most adaptable solution = requiring the most jointing and finishing at the site. B- SLAB & COLUMN: A single horizontal element eliminates the necessity of infill between beams. C- PANELS: Continuous load-bearing flat components distributing the loads on one axis; limiting the planning on that axis =± party wall contributing to soundproofing & fireproofing. D- INTEGRATED JOINT: Monolithic component simplifying the connections by locating the joint outside the geometrical meeting point and taking positive + negative moments.

In highly industrialized countries, FACTORY-MADE 3D MODULES are quite relevant. Road transportation rules in North-America are permitting modules up to ± 4.5 m X 14m whereas the Japanese modules are limited to ± 2.5 m X ± 5.6 m X ± 2.8 m, which implies more site connections. In developing countries, lack of large investment potential, difficult transportation conditions and limited heavy handling equipment are usually such that the factory-made 3D module would normally be prohibitive.

Table 2. The two types of Factory-Made Modules

II- FACTORY-MADE 3D MODULE • The building is made of 3D	E- SECTIONAL MODULE: Small and easy to transport modules needing a complementary component or process once at the site.

modules entirely assembled + finished at the plant • Bulky transportation • Simple site connections	F- BOX: Autonomous unit entirely completed at the plant.

The HYBRIDS are aiming at the best of both worlds. The Load-Bearing Service Core is maximizing factory production for the complex parts of a residential building, transporting only high value-added modules and reducing the job-site activities to simple dry connections. With Site Mechanization, the envelope and the partitions subsystems are most likely left to plug-in components in the case of industrialized countries or to local materials in other countries; in both cases, the service and equipment sub-systems, being complex and compact, are better served by being factory-made components or being integrated in a single non-load-bearing 3D module.

Fig. 3 The three types of Hybrids

III- HYBRID • Manufacturing the complex parts at the plant • Transportation of the complex parts and of mobile tooling to complete the building • The site is both a factory and a final assembly line	G- LOAD-BEARING SERVICE CORE: The "service" area is built at the plant within a value-added 3D module with structural capacity in order to support slabs, envelope panels and partitions generating the "served" area once at the site. H- MEGASTRUCTURE: Framework to stack boxes or panels in order to reach a high-rise status without piling them up (= prohibitive structural redundancy). I- SITE MECHANIZATION: Transforming the site into a plant, at least for the structure and other heavy operations whereas the other subsystems are usually compact and sophisticated enough to justify factory production.

THE PATH TO FULL INDUSTRIALISATION IN DEVELOPING COUNTRIES

Instead of following the traditional craftsmanship approach still applied in most developed countries, the developing countries have the opportunity to do better: to fully apply industrialisation.

Low capital investment

Based on the fact that an industrial organisation could only operate at the final assembly stage, a low level of capital investment would easily be reached through continuous subcontracting with one manufacturer for each sub-system: structure, envelope, partitions, equipments and services; all governed by "Interfacing Rules" together with "Modular Coordination".

In terms of individualisation, the building system can apply the four strategies to individualise (mass-customization) within mass-production mentioned above, or, in developing countries where labour (although mostly unskilled) is available, to leave the construction of the facades and the partitioning directly to the users**.**

Three relevant processes for developing countries

Comparing the advantages and inconvenients of the 9 types of systems described above to the general conditions of developing countries where mechanical equipments as well as skilled labour are limited, where road conditions are variable and where land is readily available outside the large cities, three types of systems are more relevant:

- In the Kit of Parts family, a few simple factory-made Post & Beam / Integrated Joint components produced in large quantity can easily be assembled on the site and generate a diversity of building forms. Combined with a factory made service block, they would provide a sound skeleton "Support Structure" open horizontally and vertically to lightweight prefabricated panels or local materials installed by the occupants themselves.

- In the Hybrid family, small local plants organised and tooled appropriately (low-tech Site Mechanization) can produce simple interlocking components suitable for self-help construction; here too, a factory-made service block would be advantageous to complete the unit.

- Still in the Hybrid family, a lightweight load bearing Service Core where the complex parts of a building are factory made can support a basic shell built locally around it using local resources.

CONCLUSION

What are the advantages of industrialising the building industry in developing countries? For the client-buyer-user, a "ready-to-wear" product offering better quality at a lower cost (a reduction of 15 up to 20 % in general, up to 30% with self-help); for the manufacturer, continuity to amortize the investment in a process that can simplify production; for the builder, an up-to-date technology that can deliver precision in a timely fashion; for Society, hopefully a truly contemporary and representative architectural language.

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Rubblizing Concrete Pavements Using Resonant Vibration Technology

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Abstract
The paper presents an engineering and technical description of the technology known as pavement concrete rubblizing, which is used for both, concrete pavement rehabilitation and as a demolition method for concrete recycling. The paper presents the results of the first Chilean experience with rubblizing and demolition and recycling. Pavement rubblizing may be defined as a technique that fractures the concrete slab into angular interlocked pieces using a "resonant vibration" machine. Once concrete pavement has been rubblized, an overlay is built on top of the fractured material. This paper also includes a summary of: engineering principles of the dynamic process for concrete Rubblizing and criterion used for structural design and summary of the construction process.

Keywords
Rubblizing, recycling, pavement, concrete, demolition.

INTRODUCTION

Around the world and particularly in Chile there are a large number of concrete pavements located in: urban and interurban highways, airports, ports and industrial sites. All pavements suffer a progressive distress, produced by transit loads and climate (temperature, rain, humidity). Pavement durability will depend mainly on: the quality of the original engineering project, the construction quality and the maintenance strategy carried out during the design period.

Several techniques allow extending pavement life. These techniques may be classified in two categories: maintenance and rehabilitation [Thenoux, 2003a]. Maintenance techniques improve pavement functional capacity and help to extend pavement structural life while habilitation techniques increase or replace pavement structural capacity, recovering the structural condition. Pavement maintenance must be carried out in an early stage of pavement deterioration, and generally rehabilitation is normally applied when pavement structure is in poor or terminal condition.

The most common rehabilitation techniques used in rigid pavements within Chilean national road network consists in both, direct asphalt overlays or granular material overlays plus an asphalt layer on top. In general, asphalt overlays are more cost-effective compared to concrete overlays [NAPA, 1995]. Asphalt overlays improve functional pavement condition and increase structural capacity; however most overlay technique will show reflective cracking within a relative short period of time (may start the first year of service). Although, most concrete fracturing slab techniques have demonstrated to be effective, delaying or avoiding crack reflection, distress models of rehabilitated sections through slab fracturing methods have demonstrated that best long term behavior is achieved when using rubblizing technique with a resonant breaker [NAPA, 1995].

CONRETE PAVEMENT REHABILITATION

In many aspects, pavement rehabilitation is more complex than a new pavement design. A suitable rehabilitation policy should aim to extend structural design period of an existing pavement, but also to reduce investment costs. Several rehabilitation methods of concrete pavements are available. These are : Do nothing, slab replacement, hot mix asphalt (HMA) overlays, portland cement concrete (PCC) overlays and reconstruction [NAPA, 1995].

It is feasible to build overlays using either concrete or asphalt material. Nevertheless, asphalt is generally more economical and technically accepted, particularly if transit time delay costs are incorporated into life cycle cost analysis [NAPA, 1995]. HMA overlays will restore ride-ability, improve long-term functional pavement performance as well as increase the structural capacity of the existing pavement in a most economical manner. However, one of the most significant design problems of this type of rehabilitation is the potential to develop reflection cracking distress through the HMA overlay. This phenomenon may eventually cause a serious loss in performance and service life of the HMA overlay.

Reflection cracking of HMA overlays

A simple way to explain the crack reflection mechanism is the following: when asphalt overlay is placed on top of a deteriorated concrete pavement, pavement joints or cracks will induce stresses originated from temperature gradients and/or transit loads. The horizontal and vertical movements induce tension and shear forces. This complex combination of both tensile stresses and shear stresses at the interface of the HMA overlay will eventually cause the development of cracks across the entire thickness of the HMA overlay. To prevent or delay reflection cracking, fracture slab technique offers one of the most economical and successful ways to eliminate reflection cracking of HMA overlay placed on existing PCC pavements [NAPA, 1995].

Fracture slab techniques

Fracture slab techniques have been used extensively in United States during the last 20 years, supported by different agencies: AASHTO (American Association of State Highway and Transportation Officials), NAPA (National Asphalt Pavement Association) and Asphalt Institute. The major categories of these techniques are:

- **Crack and Seat (or Break and Seat):** The objective of the Crack and Seat technique is to reduce reflection cracking in the HMA overlay by reducing the effective slab length of the PCC pavement. The cracking process requires high energy which is obtained through a big load and high amplitude. Seating of the broken slabs after cracking is intended to re-establish the support between the base or subbase and the fracture PCC slab.
- **Rubblization:** The objective of the Rubblization fracture slab technique is to eliminate reflection cracking in the HMA overlay by the complete destruction of the existing slab action of the PCC

pavement. Resonant Rubblization also de-bonds all reinforcing steel in the slab. This technique is applicable to all types of existing PCC pavements.

RUBBLIZING USING A RESONANT BREAKER

The rubblizing process using a resonant breaker is defined as a fast fracturing process, where a machine breaks the pavement into small interlocked pieces. The principle of the machine is a massive steel beam, which vibrates through a frequency close to resonance. The vibratory motion is transmitted to a hammer that is moved along the pavement surface in front of the machine (Figure 1-(a)).

The rubblizing fracturing pattern and hammer is shown in Figure 1-(b). The final rubblized product is a high modulus granular base layer, achieving a relatively high structural capacity with an excellent performance. One of the most remarkable properties of the technique is that does not affect the underlying base and sub-grade materials due to the very low amplitude in which the resonant load is applied: vibration energy is entirely absorbed by concrete [Resonant Machines, 2005]. The machine allows setting the beam dynamic parameters (amplitude and frequency). Through a microprocessor the machine controls particle size of the fractured slab optimizing the rubblized material properties.

The resonant beam is the most important component of the machine, since it is the device that transmits the energy to the concrete slab. Vibration is induced on the beam by the hydraulically driven eccentric weights, which convert circular motion into vibratory motion of one mode. Generally, the beam works in amplitudes between 125 to 250 mm and frequencies between 42 and 46 Hertz. Once the vibration hammer starts to work at the optimal frequency and amplitude, rubblizing a concrete slab may be achieved at a rate of 700 square meters per hour [Thenoux *et al*., 2004a].

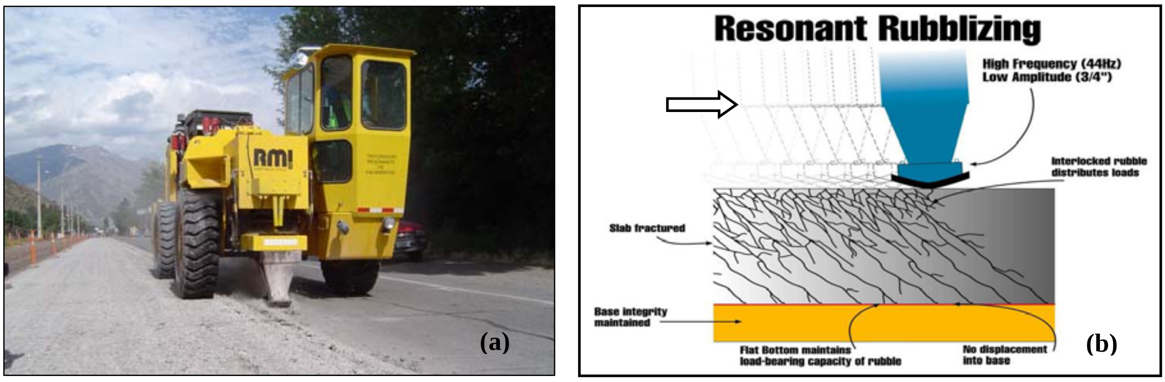


Figure 1: Rubblizing technique at 60-CH Highway Chile (a) and concrete pattern fracture (b)

Technology advantages

The rubblizing presents different advantages from technical, economical, environmental and operational point of views. These are:

- **Technical:** The rubblizing technique is a construction method similar to a reconstruction since all failure pattern of the existing pavement are destroyed (cracking, spalling, pumping, rough riding, lost of bonding, raveling, faulting, etc.) producing a new base material. The new base material will have a structural capacity in excess of a good asphalt base layer. Pavement research programs at USA have followed different concrete fractured pavement projects with an asphalt layer on the surface during its operational life. Measured through PCI (Pavement Condition Index), rubblized pavements have reached the best performance [NAPA, 1995]. From the structural point of view the subgrade is not affected by the rubblized process and reflecting cracking is completely eliminated.

- **Economical:** Important cost differences exist between rubblizing and traditional reconstruction or rehabilitation techniques. A comparative analysis was made at Arkansas, USA. In this study, the total reconstruction cost was 3 to 4 times greater than the rubblizing alternatives [Asphalt Institute, 2001]. Other States have done the same analysis and the rate reconstruction/rubblizing is about 3:1 to 4:1 [Resonant Machines, 2005]. One of the main factors that reduce rubblizing cost is the efficiency and effectiveness of the process and the high performance of the machine (700 m^2/hour or 1.5 km on a single lane per day).

- **Environmental:** This technique can be considered as a pavement recycling method since is possible to reutilize the rubblized material in-situ. Recycling pavement materials generate the following environmental advantages [Thenoux *et al.*, 2003b]: Reduces haulage and new material volumes from borrow pits, reduces haulage of waste concrete, reduces pollution associated to construction and demolition processes (dust, smoke, noice), reduces driver's user impact and cost during the construction, construction time is shorter compared to other rehabilitation techniques, reduces energy consumption and emissions, etc.

- **Operational advantages for pavement demolition:** Rubblizing technology can be applied in rehabilitation as well as in pavement demolition projects. Compared to traditional demolition techniques, is possible to identify several advantages: Rubblized concrete material swells only 20-30%, reducing transportation volumes compared to high impact broken concrete which swells more than 100%, the rubblizing material has a smaller particle size, thus the material may be easily recycle in plant, the demolition process does not affect adjacent structures, etc.

CRITERIA AND METHODS FOR STRUCTURAL DESIGN

The structural design method for rubblized pavement is supported by the following guidelines: Structural Design Guide, AASHTO [AASHTO, 1993], Manual Series, Asphalt Institute (MS-17) [Asphalt Institute, 1995]. and Information Series, NAPA (IS-117) [NAPA, 1995]. The most accepted structural design method is AASHTO, which uses Structural Numbers and where the basic design equation is:

$$SN_{ol} = a_{ol} * D_{ol} = SN_f - SN_{eff} \qquad \text{(Ecuación 1)}$$

$Where: SN_{ol} =$ Requerid overlay structural number.

$a_{ol} =$ Structural coefficient for the asphalt concrete overlay.

$D_{ol} =$ Requerid overlay thickness.

$SN_f =$ Structural number requerid to carry future traffic.

$SN_{eff} =$ Effective structural number of the existing pavement after fracturing.

Determine the overlay thickness is a simple procedure, but is necessary to know the material structural coefficients. AASHTO recommend the structural coefficient between 0.14 to 0.3 [AASHTO, 1993]. Recommended structural coefficients by NAPA are showed in Table 1 [NAPA, 1995].

Table 1: Structural coefficients used for rubblizing material

Reliability (%)	a_2
75	0,34
85	0,30
90	0,29
95	0,26
99	0,20

FIRST CHILEAN EXPERIENCE WHITH RUBBLIZING

The first application in Chile was done late in year 2004. A 300 m, test section was constructed in the main Chilean international highway which connects Chile and Argentina through the Andes mountain. This, road may be considered as the most heavily traffic road in Chile.

Figure 3-(a), shows typical original conditions of the concrete existing concrete pavement. The test section was located between a relative large construction project (aprox. 50 km) where part of the project was reconstructed and an important part was being rehabilitated using a granular base overlay plus asphalt overlay (Figure 3-(b)). This technique is widely used in for highway concrete pavement rehabilitation in Chile. Although, direct asphalt overlay was also considered this is not included in the analysis, since due to the actual pavement conditions and traffic there is a high potential for reflecting cracking.

Figure 3: typical pavement original conditions (a) and overlay with granular base (b)

The test section was selected from a segment that according to the engineering project was going to be overlay (with granular base plus asphalt overlay), so us to compared performance and rehabilitation costs. Figure 4, shows the two rehabilitation alternatives to be compared.

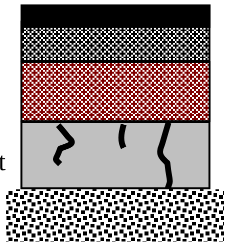
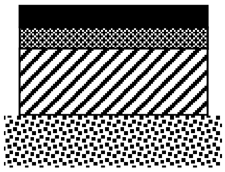
Overlay	Rubblizing
5 cm asphalt layer 1 7 cm asphalt layer 2 15 cm de granular base (CBR > 80%) 20 cm existing concrete pavement 	5 cm asphalt layer 1 5 cm asphalt layer 2 20 cm rubblized concrete pavement 

Figure 4: Rehabilitation alternatives

Comparisons

The first analysis was done by evaluating total construction time for a similar length of road. Considering only those periods of time which were strictly related to the construction process it took less than three days for the rubblizing alternative and seven days for overlaying. Also, reconstruction was evaluated but they were so many other problems that a reconstruction section of the same length extended for more than three weeks.

A second analysis was a direct cost analysis for different alternatives using actual costs and reference [Thenoux, 2004b]. Rubblizing, has the least cost compare to overlaying and reconstruction.

Table 2: Estimated direct costs

Alternative	Cost (US$/km)	Relation
Reconstruction	161.875	2,1
Overlaying	123.253	1,6
Rubblizing	78.796	1,0

The third analysis that was planned to do, was to study and compared performance. Unfortunately ones the road was given to the traffic a heavy spring rain was experimented for three continuously days. Drainage design was very poor so many sections of the road where completely soaked for this extended time while heavy traffic was going through.

Figure 5-(a) and Figure 5-(b), shows how the road looks after the rain. Although was not possible to do traffic performance analysis it was possible to prove drainage performance of the rubblized layer is excellent.

The road was damage almost in all its extension. Since drainage was very poor water did not drain out from the granular overlay. It could not drain laterally fast enough due to the lack of lateral drainage and it could not drain downwards due to the existing concrete pavement. The section that was Rubblized being located under the same conditions performed very well. The rubblized layer is not water susceptible and it drains laterally very easy, thus going good performance of the asphalt overlay layer.

Figure 5: Rubblized section (a) end overlay section (b) after the rain

The last analysis that was done was a sieve analysis of the upper part of the rubblized material. This is composed approximately with 15 % sand and 85% medium coarse size. The sieve analysis for each size is shown in Figure 6. Based on this results this material may be used directly in other applications without further crushing.

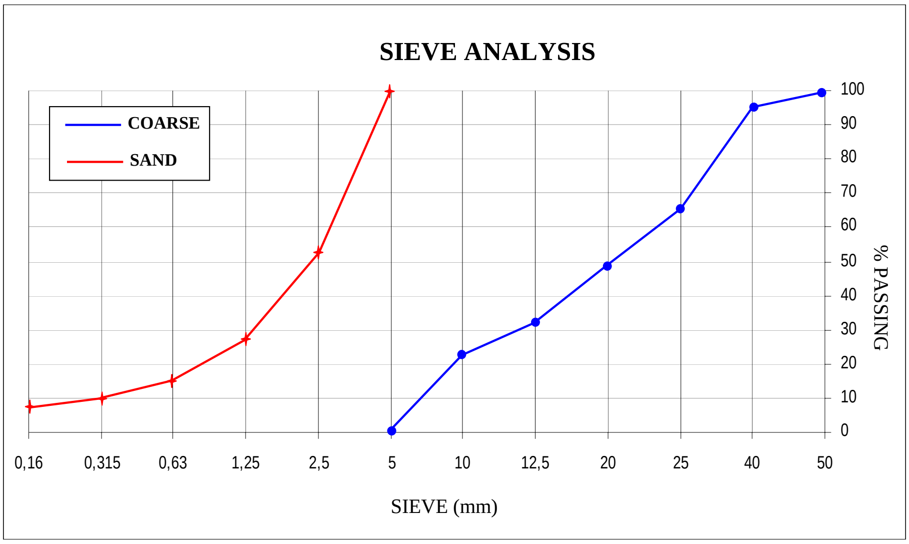


Figure 6: Sieve analysis of rubblized material

CONCLUSIONS

According to the information presented above, rubblizing is a feasible technique from the technical, environmental and operational point of view. The technology reduces environmental impact, haulage distances and energy consumption. Is relatively fast and provides high confidence on the properties of the final product. The technique fractures distressed concrete, destroying all failure patterns and does not affect the underlying granular layers (subbase and sub-grade), nor does it effect underground utilities. The final product is a high modulus base, suitable for an asphalt overlay.

Rubblizing has been widely accepted in United States. The technique is recommended by known technical institutions as Asphalt Institute, NAPA and AASHTO. Further, structural design methods are available from guidelines written by these institutions.

The test section performed in Chile, was subjected to an inspected rainfall but in turns it was possible to prove the effectiveness of the rubblized technique and the good drainage properties of the rubblized material. Although was not possible to compare the test section traffic performance with the overlay alternative, at this time after 5 month of service the rubblized section is outperforming. Cost and construction time was compared and it was proven that rubblized will offer greater economic advantages and construction time reduction.

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Strategic Niche Management a Support Tool for Innovation in Construction

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Abstract
The difficulty of introduction and diffusion of new technologies in the market is a hot item in the innovation literature. The innovation theories point at technological regimes as key elements in diffusion, acceptation and application of new technologies as well as the importance of interactive learning processes, the development and supply of complementary inventions, the need for institutional adaptations -in management, organization and the overall institutional framework in which firms operate-.
The findings of a case study which was carried out on the introduction and diffusion of an innovative building technology in the Indonesian residential construction sector underscore the theories. The issue that is discussed further is how to make use of Strategic Niche Management (SNM) as a support tool for wider diffusion of new technologies in the construction industry. The examination of generic views on how socio-technical niches are created and managed by various actors, and how public policy can contribute to the wider diffusion and development of new technologies and systems by building upon these niches uncovers more fundamental issues regarding the diffusion of innovative technologies and construction industry development.

Keywords
Strategic niche management, innovation, diffusion, construction industry

INTRODUCTION

The construction industry everywhere faces problems and challenges: globalisation, increasing competition, evolving new technologies, population growth, urbanisation, extensive need for housing and the need to reduce pollution substantially. Ofori stated that in the developing countries however, these difficulties and challenges are present alongside a general situation of socio-economic stress, chronic resource shortages, institutional weaknesses and a general inability to deal with the key issues. (Ofori 2002) Many of the construction projects in developing countries are beyond the capability of their industries to undertake, owing to the size, novelty and complexity of those projects (Drewer, 1997). Therefore, these developing countries face the import of some construction activities.
A considerable variety of technologies has been developed and became available in the global market over the last years. Innovations could help solving (some of) the problems faced by the construction industry. Innovation does not only refer to the *invention* -i.e. the development of new

technologies (products and production processes) and knowledge-, but it also includes the *diffusion* (acceptation, adoption) and *implementation* of these. However the diffusion and implementation of new technologies is progressing slowly in the construction industry. Globalisation opened the opportunities for industries to catch-up by making use of imported foreign innovative technologies. Construction however is still essentially a local industry, and construction labour markets are deeply embedded in local laws, regulations and institutions. Many technological opportunities are under-utilized. The challenge is to find better ways of introducing and diffusing promising technological opportunities and thereby alleviate problems in the construction industry.

THEORETIC CONSIDERATIONS

Innovation, diffusion and implementation

Innovation or technological development takes place in on-going cyclic processes (Egmond 2001). Innovations can either be the result of local R&D efforts, or they can be acquired from abroad (international technology transfer). After their introduction, the innovative technologies can be adopted, adapted and - if that is done successfully - diffused within a community or between communities. The cycle is on going, because new needs keep on emerging in every modern society, be it because of changing rules and regulations, demographic changes, technological changes, or other developments.

Implementation of technologies typically refers to the process of selection, adoption and adaptation of technologies and it is generally applied to establish development of some kind. A technology is more beneficial to more people if the ones benefiting from it can understand and adapt it to their (local) needs. Thus the technologies most adapted to local circumstances are the ones that are adopted most widely.

Diffusion is the rate of adoption of (new) technologies. It takes place as soon as the invention is applied in production processes of companies or institutions, or by people, causing the technology to spread in society. This spread is accomplished through human interactions; communication between members of a social system (Rogers, 1995). The more companies, institutions or people adopt the technology, the more widely it is diffused.

The role of innovation in improvement of production performance and competitiveness has developed considerably over the past decade in economic literature. Both extensions of the neoclassical theory (e.g., new growth theory) as well as alternative approaches have emerged, in attempts to explain the phenomena of innovation, including the broad field of evolutionary economics. Historians and sociologists have also used evolutionary concepts for the understanding and explanation of the rate and direction of technological developments. The core concepts in the evolutionary theories are innovations and technological regimes within innovation systems. The last refers to the network of interrelated individuals, organizations and enterprises who share a common field of knowledge and interest regarding innovations. (Malherba 1999)

Technological regimes are seen as social constructs -a pattern- made of knowledge, rules, regulations conventions, consensual expectations, assumptions, or thinking shared by stakeholders in an innovation system, which characterize professional practice and which guide the design and further the development of innovations (Kuhn 1962, Dosi 1982, Nelson & Winter 1982) A *regime shift* is a significant, profound and irreversible change from one fundamental view to another, a different model of behaviour or perception. (Nelson & Winter 1982) Innovation theories point at *technological regimes* as key elements in diffusion, acceptation and application of new technologies as well as the importance of interactive learning processes and the development and supply of complementary inventions. There might also be a need for institutional adaptations -in management, organization and the overall innovation system in which firms operate- when new technologies are diffused and implemented. Douthwaite (2002, p 75) stated in line with the above "Adapting the parable of the seed & the sower, a technology, however good it is technically, will only be adopted and prosper if it falls on fertile ground." Thus an implementation and diffusion of an innovative technology is considered to be successful if it fits in the prevailing technological regime that characterizes the professional practice of actors in the innovation system. The actors can be found at 1) international –; 2) national- ; 3) sector-; and 4) company- or project level. The characteristics of the innovative technology are seen as a benchmark to assess whether it meets the knowledge, rules, regulations conventions, consensual expectations, assumptions, perceptions, objectives of the actors in the innovation system. Once this is clear, then promoting or constraining factors that affect the diffusion and implementation of the innovative technology in question can be determined. The Strategic Niche Management (SNM) approach is considered useful to deal with these findings in order to stimulate the diffusion and implementation of innovative – and promising- technologies

Technological niches and strategic niche management

In terms of the network approach and equivalent to the innovation system as the organizational environment in which innovation takes place, one also can distinguish a technological environment as a sort of network among innovations. Nodes of the network are innovations. Several innovations thus are embedded in the network of the technological environment. The position of an innovation in the network is its technological niche in the domain. Thus the idea of a technological niche means that a certain technology exists -or is developed- alongside other technologies, whilst it serves a limited domain of application. From historical evidence can be learned that new technologies often received some kind of protection and support, usually in the form of stimulating a particular market demand and technology development programmes, which created a niche for a fledging technology. A technological niche is different from a market niche. The market potential -expected rate of return on investment- plays a role in technological niches. Like markets, technological niches are carried by networks actors (innovation system - the institutional framework-) and by a set of assumptions (technological regime).
The Strategic Niche Management (SNM) approach thrives on the idea of technological niches and the possibility to manage these. (Schot & Rip 1996) SNM is useful for technologies that are promising but that are undersupplied by the market because of high uncertainty, high up-front costs, or because the technical and social benefits are insufficiently valued in the market place. Different actors in the innovation system may be the niche manager: policy makers, a regulatory agency, local authorities, a citizen group, private company, an industry organization, or a special interest group. The niche manager may be a person or a (newly founded) organization. Governments generally have a special role as a facilitator to stimulate that the diffusion and implementation takes place.

THE CASE OF AN INNOVATIVE CONSTRUCTION TECHNOLOGY FOR RESIDENTIAL CONSTRUCTION IN INDONESIA

The subject of the case study is a foreign innovative construction technology that comprises lightweight concrete blocks, lightweight building panels for both external walls and internal (partition) walls, floors and roof tiles, etc.; either pre-cast or cast in situ. Experiences with the application of this system in the construction of hospitals showed that it seems reasonably suitable to provide a technological solution for the housing shortage through its application in the sub sector of residential building construction. The objective of the case study was to determine the opportunities and bottlenecks with regard to the implementation and diffusion of this innovative technology in the residential construction sector. The scope of the case study has been on West- and Central Java, Indonesia. The need for housing is greatest in this densely populated part of Indonesia.

Data collection took place by means of literature studies, observations and interviews among the major actors in the innovation system: government officials, architects, contractors, project developers, material experts and (potential) house owners. (Vloerbergh 2005)

Innovative light weight concrete system

The blocks and elements owe their light weight to the foam that is added to the mixture of cement, sand and water by means of a mobile Foam-Concrete Machine. The additional chemical substance in the mixture forms bubbles of air once the concrete hardens giving it a fine cellular structure. This causes the mass to lower from the standard 2.4 tons per m^3 to a much lighter material (the exact weight depends on the sand and cement rates used in the mixture). The production process needs minimum handling. The Foam-Concrete Machine mobility enables on-site production of the blocks and elements. This eliminates transport costs and also damage due to transport. Moreover the possibility to prefabricate the elements in situ implies a higher speed of building and a consistent quality. This distinguishes this technology from other systems such as red bricks and normal concrete blocks which are in majority used in residential construction in Indonesia.
Like ordinary concrete, the material can be mould to any desired shape or sizes. The size of the elements which were investigated in this case study is 60 x 30 x 10 cm with little deviations of standard size. The light weight is combined with a good mechanical strength- which reduces the dead load of a structure. The density can be precisely varied -depending on the amount of foam added to the cement mixture- to suit particular specifications of strength. The investigated elements -with a density of 800-1000 kg/m3- have a relatively low compressive and tensile strength and can be used for non-load bearing walls only. The buildings thus require a structure with accurately realized columns and beams. The material is fire resistant, does not absorb much water and has a low thermal conductivity, high noise and thermal insulation properties and it is vermin and rot proof. The elements are easy to process, can easily be sawn, nailed and drilled by using conventional tools. The speed of construction is rather fast and the work can be executed mostly with the help of unskilled labour. Extra workers or tools like small cranes are sometimes desirable when lifting the elements above waist height becomes problematic. The surface of the blocks and elements is rather smooth and looks neat without finishing, but finishing can be done as usual with traditional stucco, plaster, paint or tiles. The bonding of the concrete with the plaster can easily be improved by scratching the sides of the elements with a nail, which creates little slots to enhance the connection.

Professional practice in the innovation system of the residential construction sector

Aspects of the technological regime -knowledge, rules, regulations, conventions, consensual expectations, assumptions, objectives- which characterize the professional practices of the major players in the innovation system of the residential construction sector in West- and Central Java were assumed to hamper the take off of the diffusion of the innovative light weight concrete technology.
The major actors in the innovation system of the residential construction industry in West- and Central Java Indonesia are (a) direct technology utilizing firms and organizations and (b) indirect technology promoting and supporting agents and groups. The *direct technology utilizing* actors have a major say in the selection of a technology. This group comprises (1) Public sector agencies (Ministry of Works) & Project development and real estate agencies; Architects and engineers; Contractors and sub contractors; and (2) Public and private sector clients (individuals, property companies, investors).
The Ministry of Public Works, Provincial and local authorities, project developers and real estate agencies generally are the initiators of residential building projects in Indonesia. The plans are realized with a building team (architects, engineers and contractors) which generally takes notice of

the particular market requirements for residential buildings based on functional needs and expectations as well as on the clients' affordability and willingness to pay. House owners and tenants belonging to the lower income households do not have any decisive power in case they buy or rent a house that is offered by the real estate agencies or governmental agencies. The major criteria based upon which construction technologies and building materials are selected in the residential construction sector in Indonesia appeared to be: (1) price, (2) perceived performance in terms of quality, technical durability and strength, (3) availability, ease of acquisition.

Construction technologies for residential buildings and the technological regime

Red brick, batako and concrete blocks masonry are the construction technologies that are most commonly used for houses in Indonesia. With no exception, all respondents prefer red bricks (19x9x6.5 cm) as building material.
Batako is a building element (40x20x10cm) that can be used for non-load bearing walls. It is composed of a strong mortar made out of a mixture of finely ground pozzolana (fine sandy volcanic ash; in majority black, white and grey coloured), lime and water. Batako masonry is cheaper than the red burnt bricks and conblocks, since the major component pozzolana is practically free of charge available in nature as well as a residue from other production processes (fly ash from coal fired power plants, silica fume from silicon production, rice husk ash from rice-padi fields). Batako and conblock (a sand cement mixture) look alike in terms of size and colour and they are often mixed up in speech. As a result, they both have a bad image and are associated with cheap, low quality houses. The perceived strength and durability of batako is rather bad: 50 % of the respondents consider the material weak to very weak; almost all (92 %) mentioned problems with humidity and 50% with fungus; 86 % considers the batako houses uncomfortable and noisy (72 %). The appearance of the un-plastered batako walls is considered unacceptable for most of the respondents. Batako has been used in government-subsidized housing programs for the low-income households, which also boosts its image of a poor mans material. In these houses only the exterior walls are plastered, resulting in greyish interior walls. Households were supposed to plaster the interior themselves, but this is hardly ever done. Besides batako and conblocks are less easy to handle compared to red burnt bricks, due to their size and weight. Both the compressive and tensile strength of batako is less than that of red burnt bricks. The ways to get hold of the red burnt bricks, batako and conblocks, the inputs and the required tools and equipment to produce and apply these building materials in the construction process are familiar to the actors in the residential construction sector in Indonesia. Moreover all of the needed inputs are locally produced.
The equipment to produce the blocks and elements as well as the foam and special saws needed to work with the system have to be imported for the light weight concrete elements. Other inputs - water, electricity and de-moulding oil- are locally available but need to meet particular quality requirements to ensure that quality of the blocks, panels and ultimately the wall structures is correspondingly high. Although technically the light weight concrete elements may in reality be equally as strong as red brick their strength is generally perceived as weak and too soft by the respondents. The favourable insulation characteristics of the light-weight concrete blocks and panels appeared to be considered of minor importance by the respondents.
Since there is no familiarity with the light weight concrete construction technology the site labour involved in the production of elements and the application of these to construct walls requires extra training. Extra training is also needed for personnel involved in management of the production and construction processes (contractors) as well as for the personnel involved in marketing and sales of the light weight concrete construction technology. The cost per m^2 finished wall is approximately 5 Euro/ $m^{2\,(}$60.000 Rp/$m^{2)}$, which is twice the cost of a wall with red bricks, but lower than the cost of a wall with normal concrete blocks (approx. 6 Euro/ m^2)$^{.}$ However the higher costs per m2 are counterbalanced by the savings on the cost of transport and the input materials, as well as of

foundations and structure thanks to the light weight of the elements which reduces the dead load of a structure. Moreover compared to red bricks and normal concrete blocks the production of the light weight elements requires less energy and produce less air polluting emissions.
The innovative light-weight concrete blocks and panels showed to have some advantages compared to the traditionally preferred construction technologies. However the light-weight concrete technology has not yet gained a status of extensive recognition. Since it is recently introduced in the Indonesian residential construction sector, people will generally not consider it an alternative for red brick or batako. It appeared very hard for any new product to compete with the solid strong and simple image of red brick.

Influence of in-direct actors on residential construction

Indirect actors in residential construction sector may support and regulate the diffusion and implementation of innovative technologies by means of the provision of information, certain required knowledge, finances, etc. The *major indirect actors* are (1) Building material and equipment suppliers; Technology and knowledge supplying institutions such as R&D institutes, educational institutes, consultants (2) Innovation supporting and regulating institutions such as international organisations, national, provincial and local government and public agencies, branch organizations, financing institutions.
An important player in this case study is the foreign enterprise that imports the basic materials and equipment for the light weight concrete construction technology. They have all information and knowledge for the management, production, sales and construction. They also have the financial resources to overcome the initial investments in the diffusion and implementation of the innovative technology. Besides they have relations with the Dutch Indonesian Chamber of Commerce at Jakarta which is useful for the dissemination of the information and the technology.
Relations with other organisations and institutes in the innovation system of the residential construction sector, which are relevant for the dissemination of information and technologies, were at the time of the case study not yet strong enough established. Examples are the branch organisations such as the REI (Real Estate Indonesia), the branch organization of project developers and real estate agencies, which acts as an information centre, channels knowledge, stimulates capability building, lobbies in the politics, etc. Contractors & sub contractors are associated in two associations for contractors, namely GAPENSI and AKI, which take care for the exchange of information among contractors by means of the organization of conferences and seminars; guest lectures at universities and students traineeships. Most the suppliers of materials and services for the construction industry are also united in associations, for example the Indonesian Cement Association. At agencies like BPIK, a construction information centre of the Ministry of Industry and trade, contractors, students, and other people who can gather information on innovations, technical guidelines and prices.
The Research Institute of Human Settlements (RIHS) executes R&D as input for future policies and programs of the Ministry of Works. The Research Institute for Building Structures and Materials (PUSKIM) comprises a high concentration of knowledge and documents, equipment to test building materials and building structures. PUSKIM has been involved in various pilot projects and is supposed to disseminate new information about technologies, standards and regulations, policy recommendations or research findings which generally take place through seminars or through brochures and magazines. However due to cutting back of the budget the numbers of seminars and workshops became less and the magazines have a very limited reach.
The national government indirectly influences the residential construction sector by means of the prevailing policies for residential building which are focused at an increased housing production, higher productivity, quality and decreased costs of construction. Control and implementation of the policy plans takes place by the promulgation of laws, regulations, financial (subsidies) or fiscal

measures with the involvement of governmental bodies like the Ministry of Home Affairs and the provincial spatial planning agency responsible for the design of a master plan for the province. The Ministry of Industry & Trade is responsible for industrial development, trade rules and regulations. Most influential actor in this respect is the Ministry of Public Works. Their activities include the management of a credit facility for Houses for Low Income Households; the provision of a limited amount of building materials for self-help housing and in some cases the public facilities and physical infrastructure for residential area development. The provincial authorities are considered to provide information, rules, regulations and guidelines for the national government, but they don't have the legal instruments to enforce. Local authorities –municipalities- have a lot of freedom in the way they comply with the national policy and practically more power than the provincial authorities. Budget allocation decisions are made at municipality level. This also counts for the approval of building permits which is taken care for by the City Planning Department. This department is also in charge of the implementation of housing and spatial planning policies on regional or city level as well as for dissemination of information. The local government furthermore owns the low-income houses provided by the government and thereby deals with the involved maintenance and occupancy issues.
Financing institutes influence the residential construction by means of the quality requirements attached to the provision of financial resources by them. Project developers generally finance the construction themselves and then go to a bank to arrange the mortgage for the buyers. State banks, but also private banks have a special agreement with the government for the mortgage of low-income houses. By lowering the interest rate for the target group they have the opportunity of "subsidized loans". In addition to banks, Bapetarum (House of Savings) and Jamsostek (Body of Assurances of Laborers) are also allowed to finance houses for the lower income groups. Jamsostek has built affordable apartments for low-income workers and the other where Habitat for Humanity, a charity foundation plans to build houses for the homeless.
The relations between the actors are mainly based on personal contacts and take place on ad hoc basis unless a project is realized and the building team has weekly meetings with other actors in the innovation system of the residential construction sector. Generally however, there are no paved paths for the procedures to follow and persons to contact. Therefore, the existence of branch organizations and associations and their efforts to expand are a big improvement in networking and dissemination of information.

Strategic Niche Management for the diffusion of the light weight concrete technology

The case study showed that the innovative light weight concrete technology can be considered as a technological niche, since it exists -and is developed- alongside other technologies, whilst it serves a certain domain of application and offers additional advantages compared to the traditional technologies. The case study revealed a number of opportunities and constraints for diffusion and implementation of this innovative technology that can be brought back to the characteristics of the technological regime and the professional practices in the residential construction sector in West- and Central Java Indonesia. By means of SNM a niche manager could make attempts to make use of the opportunities and alleviate the constraints. In this case it was recommended that the entrepreneur who imported the innovative technology to Indonesia should stand up as the niche manager. In SNM work Schot, Rip and Hoogma (1996) identified three mechanisms that are important to diffusion and implementation of innovative technologies. These include (a) formation of networks and strengthening of these; (b) voicing and shaping of expectations; (c) active learning processes among major actors about design and engineering specifications, user characteristics and their requirements, environmental issues, industrial development options, government policies, regulatory framework and governmental role concerning incentives for diffusion and implementation. A major bottleneck to tackle in this case is the fact that the technical and social benefits are insufficiently valued in the market place. The first and most obvious path to be taken by the entrepreneur is to strengthen the relations between the enterprise and the other actors in the innovation system of the residential construction sector, such as the branch organisations of the project developers and real estate agencies, the contractor associations, the building materials associations, but also the governmental agencies involved in industry development and environmental issues. In connections with the last the relative ecological friendliness of the light weight concrete technology can be emphasized as promoting aspect, which may help to persuade the government to facilitate the diffusion and implementation of the technology. The following step that should be taken is to investigate various activities and their feasibility to speed up the dissemination of information and knowledge among the actors in the residential construction sector in Indonesia.

CONCLUSION

The Innovation Theories and the Strategic Niche Management approach as applied in the case study have resulted in valuable data. The innovative light weight concrete construction technology that was investigated can be considered as a technological niche. The case study indicated the promoting and constraining factors in the technological regime of the Indonesian residential construction sector for a smooth diffusion and implementation of innovative technologies. However this is just a first step on a longer way to achieve a full recognition of an innovative technology among the major actors in an innovation system. By means of SNM niche managers can stand up to intervene in the hampered process of diffusion and implementation of the innovative technology in the residential construction sector to fully benefit from its technical and social advantages. Once the possible intervention mechanisms have been determined, then the feasibility of these including the dynamics between the different mechanisms should be thoroughly assessed.

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Low-cost laminated wood

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Abstract
The article reports an experimental research undertaken at the Polytechnic of Turin with the objective to produce of structural element of laminated wood characterised by low cost production obtained from the use waste listels finalized to moderate and little spans for dwellings.
The methodology is that of hybridization (cross-fertilization between a low-cost material (wooden residues) and small part of high technology: glues and advanced tests. The experimental work, has been orientated to examine the efficiency of different types of schemes, different types of glues. The production of beams involved different groups of students, such as the simulation of non specialization workforce.
The low-cost laminated wood uses raw materials which are abundant and easy to supply to the countries with important production and treatment of timber and can be at low-cost production in small to medium scale or cooperatives.
Tensile strength tests on the beam of 1.6 m and 4.0 m obtained in the different stages of the experimental study with different glues and different ways of production processes present an appropriate performance level in moderate working stress.

Keywords
Hybridization technology, beams, low-cost, wood, waste product

Low-cost laminated wood

The study starts from an experimental research based on low-cost laminated wood, trying to improve it, focusing on one of the structural elements: the beam with rectangular section. The aim is to find a sampling methodology for future experimentation. This study is based on the graduation thesis of Faculty of Architecture, Polytechnic of Turin titled *Analysis of low-cost technologies- hypothetical use of wooden residue in the production of structural elements.* by Giordano Giuseppe and Mattone Manuela (advisors Prof. Giorgio Ceragioli and prof Mariella De Cristofaro).
The methodological hypothesis of this experiment is the technological hybridization between simple materials and technologies with advanced and very advanced materials/technologies used in small quantities. This is to reach new types of innovative technologies able to respond to significant performance with particular reference to low-cost and a low environmental impact.
At the Polytechnic of Turin, Faculty of Architecture, a research on hybrid technologies has been followed thanks to research and experiments carried out at the Specialisation School of "Technology, Architecture and Cities in developing countries", with the Tests Laboratory on materials and components of the Department DISET, Didactic Technological Laboratory

LATEC of CISDA, Structural Engineering Laboratory and Technological Laboratory of DICAS.

The aim is the production of a structural element, a beam with rectangular sections in laminated wood defined as low cost both because of the conditions of the production process, as well as the raw material used: waste product obtained from the manufacturing of semi-finished products, or by-products of wood such as trunks, sawings, plywood, lists, etc
We aimed to create a highly innovative material, able to develop load-bearing qualities by:
- low cost production;
- use of production processes with a moderate technological content and unskilled workforce to promote its adoption in socioeconomic contexts such as those found in developing countries;
- optimum exploitation of forest resources, in order to, at least partially make up for the uncontrolled felling of trees;
- use of a raw material (wooden residues), which is abundant, widespread and easy to supply.

The first part of the experimental study, is expanded in the following stages conducted by architect Giordano Giuseppe and Corna Viviana during a CNR/PFEd research directed by Prof. Giorgio Ceragioli, with the collaboration of myself .

Analysis of 4 different types of low-cost laminated wood beams (9x 18 x 160 cm)

First stage of research
It was chosen to examine the efficiency of two different types of glue and two different thicknesses of laminae. 1,5 and 1 cm thick.
Combining these variants among themselves, 4 different low-cost laminated beams were produced and tested to tensile strength.
For the realization of the beams all types of wood were used, obtained from the carpentry waste reduced to laminae 1 or 1,5 cm thick, a variable but predetermined width of 3 - 4.5 - 6 - 9 cm, and a variable lenght between 20 and 60 cm .glued with ureide glue and viniyilic glue and manual vices .

For all 4 beams we can observe a regular fluctuation of the deformation (warp) with strengthening or diminishing stress. Hooke's law, that states the direct proportion between stress and deformation is perfectly respected in all the first phase (elastic).
There is a divergence from this direct proportionality about halfway to the breaking point (start of the plastic phase) when the warp is 1/200 – 1/250 the length of the span.
The laminated beam glued with vinylic glue and with laminae 10mm thick reached very interesting results of breakpoint σ (9/10 of the σ reached by a solid fir tree beam).
The performance of the beam T II was better notable both in resistance and in deformation, probably due to the fundamental role of the glue with a long seasoning period .
Comparing the 4 types of results we decided to deepen the research on the type T II thickness 1 cm and vinylic glue (seasoned 55 days). [Giordano 1995]


Fig. 1 checking of laminae


Fig. 2 gluing


Fig. 3 clamping

Deeper study on the "best" type

Second stage of research
Production of 6 identical beams type TII (9x 18 x 160 cm) made of laminae 1 cm thick.
To determine reliable safety coefficients and the same safe working σ and elastic module (E) value which can enable us to make founded and reliable predictions regarding deformation in the planning phases.

- To undertake the relation between the period of seasoning and the behaviour of the breakpoint stress, the deformations and relative recoveries, the elastic modules and the behaviour of the mid-section of the neutral axes.


Fig. 4 Tensile strength test


Fig. 4.1 Tensile strength test

Table 1. Summary of the tensile strength tests

Beam	Days of seasoning	σ breaking (daN/cm^2)	Em T. (daN/cm^2)	Em C. (daN/cm^2)	σ safety min. (daN/cm^2)	Safety coeffcient. δ	Warps Work σ.=105 daN/cm^2 (mm)	Warps work σ.= 105 daN/cm^2 (mm)
II/10	55	366	96.000	100.000	42,7	8,5	3,7	1,7 (1/870 s)
A	19	290	105.000	82.000	42,7	6,8	5,6	2,9 (1/570 s)
B	19	240	119.000	104.000	42,7	5,6	7,3	3,8 (1/400 s)
C	24	330	75.500	72.000	42,7	7,7	7,1	3,5 (1/420 s)
A'	31	290	57.000	64.500	42,7	6,8	5,7	2,8 (1/530 s)
B'	35	385	109.500	96.000	42,7	9	5,5	2,7 (1/550 s)
C'	31	379	93.500	85.500	42,7	8,8	5,5	2,5 (1/600 s)

The appearance of the beams in the experiment are similar to those produced industrially. This makes favourable to wooden beam floors and for the open beamed roof structures for residential buildings with reduced space and for small covered structures in the open air.

400 cm beams (12.5 x 30 x 400 cm)
Third stage of research
Based on the results obtained from the previous experiments we could begin a new stage of the research: production and testing of large beams with a span of 400 cm.
Even though the second stage of research dealt in particular with a detailed study of the beam with vinylic glue with laminae with a thickness of 1 cm, we decided to produce also a ureide beam.
Characteristics:
section = 12.5 x 30 cm
span = 400 cm

bulk modulus W =1875 $cm^{3.}$
(lists of 3 - 4.5- 6- 9 cm wide) and between 20 and 60 cm long made of lists of 1 cm thick.

This beam can be employed as principal beams for floor (axle base 2 m) which can support a total uniformly distributed stress (working stress + its own weight) of 250 daN/m^2, therefore with a stress of 500 daN/m bearing on every beam.

The breakpoint tension comparison

σ breakpoint	
T400 ureide	T 400 vinylic
177 daN/ cm^2	320 daN/ cm^2

The warp (a comparison of some of the data obtained follows):

The elastic module presented in the ureide beam is elevated and very close to the elastic module of natural wood: with compression we obtain an average E = 140,000 daN/cm^2 , while with traction the value is a decidedly inferior average E = 110.000 daN/ cm^2.

The vinylic beam showed considerable deformation, accompanied by a capacity for recovery which was barely sufficient (this is due to the elastic nature of the glue). It must be noted that by remaining within the limits of the working stress the vinylic beam also displays an acceptable behaviour.
An elastic module inferior to that of T400 ureide, remained, however, close to the average elastic module previously calculated.
The "scale effect" of the deformations presented was noted, even if this was less than initially feared.
The vinylic beam offers greater resistance, but is characterized by very accentued deformations, especially if subjected to great stress.
A very positive factor is that both types present deformation which are within the maximun acceptable one, if only subjected to working stress.
Both types present an elastic module superior to that which we have previously determined (E= 75,000 daN/$cm^{2.}$.

The considerable deformation and scarce recovery of the vinylic beam in the unloading phase are negative factors to be seriously taken into account considering the resistance the product will have to mantain in time- under stress conditions- and subjected to the action of atmospheric agents. (for Euro-code 5, a beam made of traditional laminated wood loses 50% of its resistance to flexion after 10 years of stress). [Giordano 1995]

To summarize:

ureide beam	Advantage	Disadvantage
	Fewer problems in terms of workability in relation to large dimension is not very deformable, Excellent recovery of deformation. Doesn't need seasoning Displays better heat resistant qualities. Greater resistance to heat Low cost of glue Longer working time than vinylic glue	Inferior resistance Tthe glue has a certain degree of toxicity (formaldehyde emission) however, this is negligible because of the scarce percentage in which is present in the finished product 10-11%) Needs water for glue Scarce bonding in water
vinylic beam	**Advantages**	**Disadvantage**
	Greater resitance to flexion, Completely atoxic,	Considerable deformation and the scarce recovery in the unloading phase Must be seasoned (at least a once a month) before they can be worked and therefore require a storage area

New beams with melamminic glue
The second part of research considered innovative elements

- Use of glueing substance in order to get optimal cohesion with wood and in conformity with the new normative law (Eurocode 5) in force which doesn't allow the use of old glues involved in some of the previous experimentations anymore[Segatel (2001),Cremonini (2005)]
- Studies on optimal stratigraphic disposition of laminae in order to avoid mistakes during the assembling phase which could invalidate all results of the experimental tests;
- The standardization of the assembly process: studies on modification of laminae's disposition and orientation in order to verify further improvements in structural behaviour for low-cost laminated wood beams.
- Non destructive tests

To facilitate construction process and to reduce human error in the realization of economical laminated wooden beams has deepened the stratigraphy. This research was conducted by Dr. Gustavo Lenzi during the experimental stage of the course "Habitat, technology and development" at the Polytechnic of Turin with the tutoring of myself.
The laminae have been attached vertically alternating laminae of varius height to achieve an interwoven structure. In this way the lowest layer works to the maximum of the traction.
The joining points of the beams have been placed in a way so as not to coincide with the same section. The lengths have been chosen according to need to resist the compression stress (shorter listels avoid instability problems) or to resist the traction stress.

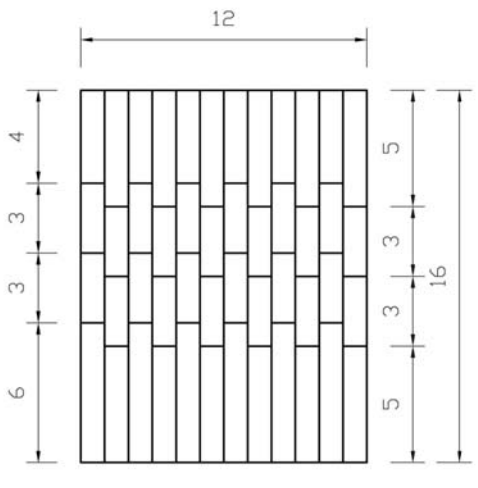

Fig. 5 vertical section of beam with vertically laminae stratigraphy

For the determination of the elastic module in flexion, were applied non destructive tests with instrument Bing, coherently with the methodological approach of technological hybridization: very advanced test instruments and calculations for low cost products.
The elastic module determination with Bing is based on the research and interpretation of the frequency spectrum of natural vibrations, applying the models developed by Bernoulli and Timoshenko. These tests were coordinated by Dr. Nicola Macchioni, CNR Institute of Florence.
Even the elastic modules obtained are as good as those obtained with natural fir-wood. [Segatel (2001)]
Breaking tensions obtained in laboratory tests reached great results, particularly for beams realised with melamminic glue which reached a breakage as good as the solid wood one (average breakpoint σ 284 daN/cm^2).
The beam made of disposing laminae vertically even exceeded the natural fir-wood's breaking tension. All beams have regular deformations (arrows and lengthenings/shortenings of the centre-line section) both when adding load and when taking it away. Centre-line deformations (all but a beam realised with vinylic glue) are less than one over two hundred (1/200) of the beam's opening in respect of the normative law in force.
Comparing two beams (160 x 9 x 15) one with a horizontal warp and the other with a vertical position it is clear of the latter an increase of breakage, σ di rottura = 423 daN/cm^2, against 313 daN/cm^2 of the beam with horizontal position .
The warp is limited with obvious benefits regarding the maximum span and the vibrations [Giraudo (2004), Lenzi (2005)]

All results are shown in the following resuming graphs.

Beam (melamminic glue)	Breakpoint σ with simple flexion (daN/cm^2)	Elastic module E (daN/cm^2)	σ safety min. (daN/cm^2)	Safety coeffic. δ	Freccia a σ sic. min. = 60 daN/cmq (mm)
industrial lam. wood	700	120.000			
natural fir-tree	400	100.000			
beam 6	270	102.220	60,0	4,5	-
beam 8	260	106.915	60,0	4,3	-
beam 10	250	103.445	60,0	4,2	-
beam 3	478	103.444	60,0	8,0	6,1 (1/245 l)
beam 4	355	75.296	60,0	5,9	4,2 (1/360 l)
beam 5a	313	86.230	60,0	5,2	2,5 (1/600 l)
beam 5b*	423	91.136	60,0	7,1	2,4 (1/630 l)
* laminae vertically					

The experiments have shown the production possibility with small firms, with low investment in machinery and unskilled labour [Gallo, 1994]

It is fundamental to expand the tests to validate these results. To carry on with viability tests, this innovative technological proposal must find interested firms to support the experiments .

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advisor Maritano Comoglio,N, second advisers Bertolini Cestari, C, Cremonini, C (University of Turin) ; Macchioni, N (CNR Institute, Florence)

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Housing Quality Requirements in Chile: a users' survey

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Abstract
Quality management systems are focused on satisfying client's requirements. For this reason, it is very important to obtain an adequate knowledge of them. The Center of Excellence for Construction Quality at the Catholic University of Chile, applied a survey recently for identifying the main quality requirements of housing users and establishing an importance ranking of them. The survey was applied to 164 inhabitants of several areas of the city of Santiago and classified at different socioeconomic levels. This paper presents and discusses the main results of the survey. The information reported here is very important for the building industry because in this way, real estate and construction companies can have better information available about what is more important for houses users and use it to improve the quality and value of their products with a clear focus on clients requirements. These results can also be useful for the construction industries of other developing countries. One of the main conclusions of this study is that survey's results show that user's quality requirements are relatively independent from the housing's type and the socioeconomic stratum of respondents.

Keywords
Housing's requirements, survey, user's opinions, quality evaluation.

INTRODUCTION

The Center of Excellence for the Quality in Construction (CECC), from de Pontificia Universidad Católica de Chile, has worked since 1997 with professionals and companies of the construction's area to promote the development and the implementation of solutions of long term to improve quality and productivity in housing and building construction in Chile.

One of these solutions is the Housing Quality Certification System, developed to guarantee the user the fulfillment of minimal standards applicable to any type of housing. The idea of this system is to provide a differentiation factor for real estate companies and to achieve better quality real estate products. During the developing of this system it was deemed necessary to identify the main quality requirements of housing users and to establish a valuation of these requirements.

THE SURVEY

The survey was applied to 164 habitants of several town areas of Santiago. Of the whole sample, only 159 surveys were considered valid.

The polled ones were classified according to their socioeconomic stratum and to housing's type in which they live. The socioeconomic classification was made according to the ranges on table 1.

Table 1 Economic classification of the polled ones according to the familiar income's range

Socioeconomic Stratum	Range of familiar income
Low stratum	Less than US$ 600
Medium-Low Stratum	Between US$ 600 and US$ 1,725
Medium-High Stratum	Over US$ 1,725

The figure 1 shows the distribution according the socioeconomic stratum and the housing's type respectively.

Fig. 1 Distribution according to the type of house and socioeconomic stratum

ANALYSIS OF RESULTS

After doing the survey it was possible to know the users' opinion about the housing's quality requirements, habitability requirements and housing's quality faults valuation.

Housing's Quality requirements

From the information delivered by the survey, it is possible to mention that the most impacting problems for the polled ones are those shown in table 2.

Table 2 Principal problems for users according to housing's type

Paired housing		Isolated housing		Department	
Problem	%	Problem	%	Problem	%
Rain filtrations	15,25	Rain filtrations	15,11	Cracks	18,75
Cracks	12,88	Cracks	10,79	Piping filtrations	15,71
Electrical faults	9,15	Piping filtrations	10,07	Rain filtrations	11,43
Piping filtrations	7,12	Lack of stability	7,91	Electrical faults	8,57
Problems with water facilities	5,42	Electrical faults	5,76	Lack of stability	7,14

It can be seen that rain filtrations is considered to be the principal problem. In departments, this problem was not considered as important, but it was mentioned too. Also important for users are the appearance of wall cracks especially when they believe it is a structural problem, because it seriously increases the perception of risk and causes insecurity regarding the housing's stability, especially in departments.

Regarding installations, the major impact problems mentioned by the people surveyed were piping filtrations and electrical faults. In general, for users the most important problems were those that can put in risk the housing inhabitants' safety (facilities, design and construction) or that can compromise the home members' health and comfort (habitability), giving a minor importance degree to those quality's faults that only affect the housing's appearance. This analysis is shown in figure 2.

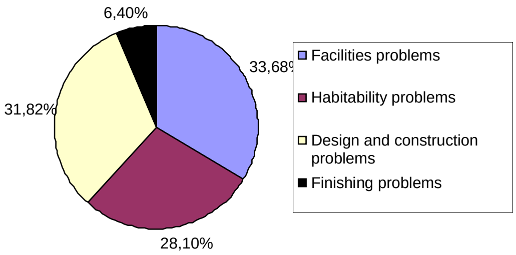

Fig. 2 Housing's problems distribution according to their impact

Habitability requirements in housings

According to the surveyed people, the habitability requirements most mentioned are those shown in figure 3.

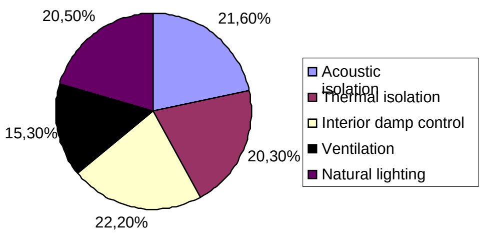

Fig. 3 Habitability requirements distribution according to user's opinion

When separating the survey's information according to the housing type, the results are those that are shown in figure 4 (100% for each requirement). This figure shows that interior damp control is more valuated in houses than in departments.

Acoustic isolation is more valuated in paired housing and in departments than in isolated houses, because of the separation between this kind of houses and their neighbors and the concern for privacy. In general, this requirement is not well considered in housing design and construction in the country.
On the other hand, thermal isolation is more valuated in departments than in houses, probably because building are more exposed to the direct solar light than houses, possessing, in general, a larger window surface.

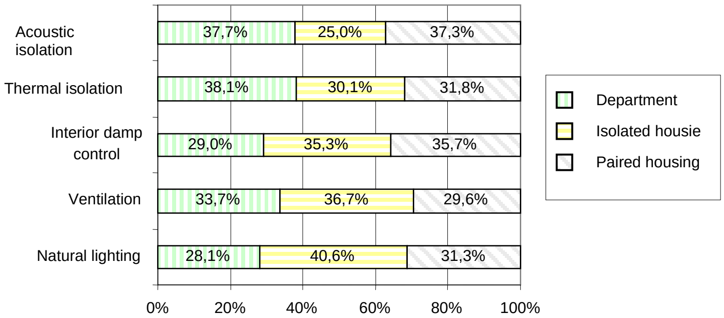

Fig. 4 Housing type distribution for habitability requirements

Faults valuation in housings

A method was determinates to combine the principal faults' importance and the occurrence frequency. For this, the polled ones were asked to qualify their housings faults' importance and the occurrence frequency. Then, these faults were classified according to table 3.

Table 3 Faults score according to their importance and frequency.

Fault importance degree	Fault occurrence frequency	Score
Very important	Permanent	100
Important	Very frequent	60
Medium importance	Sometimes	30
Little importance	Rarely	10
Minimal importance	Never	1

In addition, 3 indexes were defined to evaluate the faults:

1. Importance index (II): Average fault importance and the impact that would have for the user this problem appearance in his/her housing.
2. Frequency index (FI): Average fault occurrence frequency used to determinate the problem real frequency occurrence during the housing's useful life.
3. Average index (AI): Average of the two previous indexes used as a valuation indicator.

The results are shown in table 4. This information agrees with the information previously exposed and it reaffirms the high valuation that users give to design and construction problems, specially those faults that affect the housing's structural capacity and the roof's resistance to rain. Also, a significant valuation, though minor, is given by the user to habitability and facilities problems, giving a minor importance to the faults that affect the housing's finish.

Table 4 Indexes according to the housing's faults

Faults considered in the survey	Indexes II	FI	AI
Walls and floor's resistance problems	96	5	**51**
Interior dampness, condensation	86	14	**50**
Neighbors or street's noises	74	25	**50**
The user listens what happens in the contiguous rooms	79	17	**48**
Roof's resistance problems	93	3	**48**
Gas leak	94	1	**48**
Piping filtrations	88	6	**47**
User listens bath or shaft's exhausts	71	20	**46**
Very cold housing in winter	64	25	**45**
Leaks or rain filtrations	82	6	**44**
Electric problems	81	5	**43**
Very warm housing in summer	61	24	**43**
Poor natural lighting	71	14	**43**
Bad ventilation, scanty air traffic	74	11	**43**
Water heater wrong located	72	11	**42**
The WC, wash basin, tub or dishwasher do not evacuate well	77	6	**42**
Irregularities in floors	64	12	**38**
Walls or ceiling with uneven aspect	60	7	**34**
Not square corners	57	4	**31**
Badly doors and window's functioning	50	9	**29**
Faults in ceramics, paintings, wall paper's surface aspects	48	8	**28**
Not always warm water comes out	50	4	**27**
Faults in kitchen furniture or closets	35	5	**20**
Surfaces striped (glasses, mirrors, covers, etc)	35	3	**19**

Interior damp control was considered of vital importance by users. They mentioned a high dissatisfaction degree regarding the current situation of interior dampness, expressing that humidity filters through the walls or becomes condensed in the interior of the house. A similar opinion was obtained regarding problems provoked by rains. Their major concerns in both cases are health risks and the housing's deterioration.

Regarding acoustic isolation, this was considered more important for paired housings and departments than for isolated housings. This demonstrates the lack of minimal acoustic insulation conditions and regulation in our country. In this way, this result agrees with the study: "Measurement system of basic housings' beneficiaries satisfaction: consultancy report synthesis" carried out by the Ministry of Housing and Urban Development in 2002, which concludes that the people's quality of life level is directly related to the perception they feel about their privacy and the satisfaction for having a suitable housing's size with a good construction quality. This is the reason why the Housing Quality Certification System tries to assure that houses in the country fulfill the minimum necessary standards in order that people can feel comfortable in them. And it is necessary too diminish problems like tensions provoked by troublesome noises or the absence of privacy.

The surveyed people were also very concerned about gas facilities, because they fear filtrations and gas explosions.

Average index according to socioeconomic stratum

To analyze the influence of the socioeconomic stratum in the valuation of housing's faults, the three stratums mentioned previously were considered separately. Some of the relevant results are shown in figure 5.

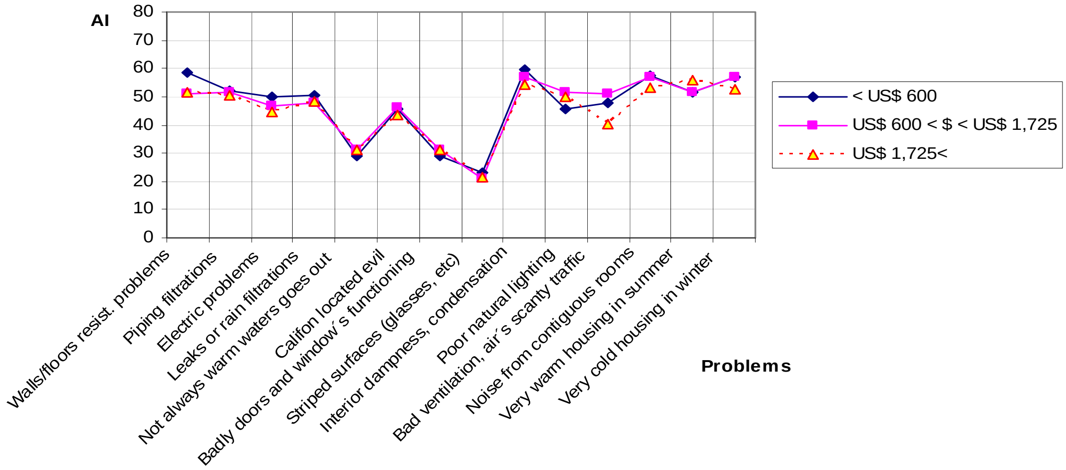

Fig. 5 Housing faults Average Index according to socioeconomic stratum

According to this figure, we can say the housing problems valuation is relatively independent of the socioeconomic stratum, which validates the approach of the Housing Quality Certification System to be considered as a minimum standard for every house, independent of their economic value.

Average index according to the type of housing

As the previous point, to analyze the valuation of users, housings were separated in the three types previously mentioned. Some of these results are shown in figure 6.

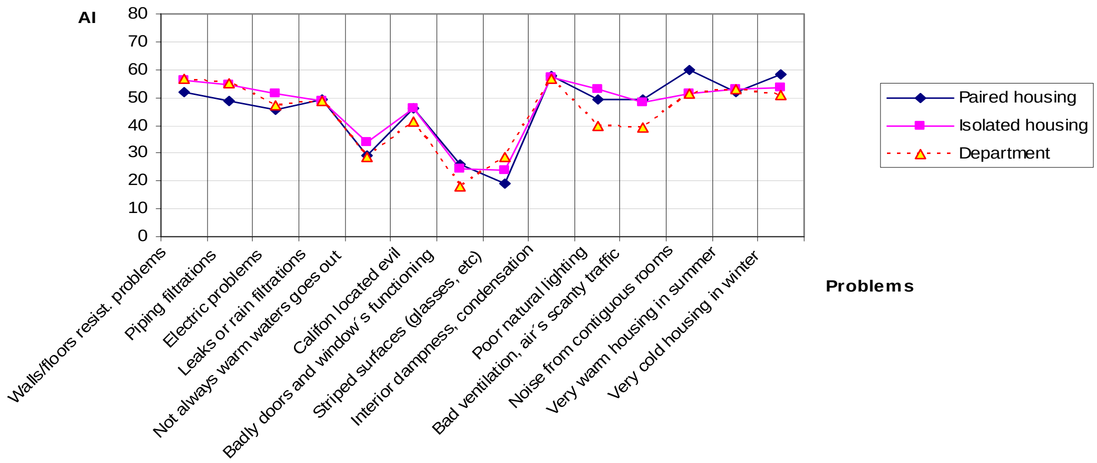

Fig. 6 Housing faults Average Index according to the type of housing

Again, being based on the graph, it is possible to mention that users valuation about problems of their housings is similar enough for the different types of housing considered in the study, except in case of the habitability faults, where for example, an isolated house user presents a minor valuation about acoustic insulation that a user of a paired house.

CONCLUSIONS

This exploratory survey was realized to identify the principal users housing's quality requirements in Chile. This evaluation made possible to establish a priority order to focus the buildings firm's efforts about construction quality towards those aspects that possess really a major valuation from users.

These obtained requirements serve to reaffirm the Housing Quality Certification Systems validity as a model which incorporates the user's needs and real requirements to achieve their full satisfaction.

Analyzing these requirements it is possible to conclude that users valuation about potential faults or housing's problems is based on the cost that means for them the appearance of a certain fault, not only for the necessary money to repair the fault, it also includes time, inconveniences and insecurity sensation, which reaffirm the importance that users give to the design and construction faults and to facilities problems.

Summarizing, the specific users requirements can be gathered in the following general requirements that any housing construction project must fulfill:

- Suitable structural design
- Construction according to specifications and procedure
- Good quality materials
- Facilities functionality
- Comfort:
    - Controlled dampness
    - Suitable acoustic isolation
    - Suitable thermal isolation
    - Suitable ventilation
- An efficient rain water evacuation system
- Good quality finishes.

The survey's results also show that the different requirements' valuation tends to be practically identical for the different socioeconomic stratums and housings study types, which allow concluding that users' quality requirements are relatively independent from the housing's type and the socioeconomic stratum. With this, there is reaffirmed the Housing's Quality Certification Bases character as a set of minimal quality standards that any house must fulfill in every circumstance, independent of the economic level to which the house is directed.

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SPECIFICATIONS TO ACHIEVE QUALITY IN B.O.T. PROJECTS
The Vasco da Gama Bridge Example

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Abstract
Governments, all over the world, are using the BOT (Build, Operate and Transfer) solution to finance large infrastructure projects, when public budgets are not available. In this system, the technical aspects of design, construction, operation and maintenance (during the concession period) are developed by the concession company, after the signature of the contract, so the quality of the final infrastructure needs to be very well specified during the initial tender phase. In fact, afterwards, all the missing aspects will definitely lead to the less expensive solution, without care to achieve quality.

In this paper, illustrated with the BOT tender process of the Vasco da Gama Bridge (one of the longest in Europe), the special technical aspects that must be considered in the tender specifications, to achieve quality in BOT projects, are presented. These include the discussion of the service life, the implications on safety and durability, the definition of the construction quality procedures, the monitoring of the operation, the implementation of inspection and maintenance plans and the reception conditions at the end of the concession.

Keywords
BOT, tender, quality, bridge, service life.

INTRODUCTION

Due to the permanent shortage of public funds, governments, all over the world, are using the BOT solution (or other similar public-private systems) to finance all types of large infrastructure projects. In this solution, with the initial financing of private banks, a concession company designs, builds and operates the infrastructure. The private investment is recovered during the concession period with the operation of the infrastructure. At the end of the concession the infrastructure is transferred back to the Government authority. Examples of this financial idea can be found in history since many centuries ago but it began to be currently used in the last decade of the XX century to finance the construction of roads, bridges, airports, hospital, power plants, etc, due to the significant profits that can be obtained from these public infrastructures.

As the technical aspects of design, construction, operation and maintenance (during the concession period) are developed by the concession company, after the signature of the BOT concession contract, the quality of the final infrastructure needs to be already very well defined during the initial tender phase when does not yet exist any design. This is a very important issue of quality control in BOT projects. In fact, afterwards, all the missing aspects will definitely lead to the less expensive solution and the final quality of the infrastructure will be reduced.

In this paper, illustrated with the tender process of the Vasco da Gama Bridge (one of the longest in Europe), the special technical aspects that must be considered in the tender specifications, to achieve quality in BOT projects, are presented. These include the discussion of the service life, its implications on safety and durability, the definition of the construction quality procedures, the monitoring of the operation, the implementation of inspection and maintenance plans and the reception conditions at the end of the concession.

TENDER AND TECHNICAL SPECIFICATIONS

To prepare a BOT tender, the initial studies must clearly define the associated financial model which is usually related to:

a) *Definition of the parameters of operation* – ex: cars passing on a road or a bridge, patients attended in a hospital, etc.

b) *Definition of the concession time, by volume or* by time – the first solution ends the concession when a certain number of cars pass (lower risk, better profit control); the second defines a fixed time for the concession (higher risk). The first, due to the lower risks leads to lower costs of the infrastructure, but needs a careful control of the operation by the authorities. The second leads to higher costs of the infrastructure and less control of the operation.

After the definition of the financial model the technical specifications for the infrastructure must be developed for the tender (Branco 2004). The main problem to prepare the tender of a BOT project is that the technical specifications must be written defining the quality to be achieved during design, construction and service life of an unknown design of the future infrastructure.

Presently this is usually implemented by imposing only the application of existing technical codes during design and construction. Unfortunately this is not enough in this type of projects, because codes are mainly prepared for design phases controlled by the owner, where it is easy to impose changes. To guarantee quality in BOT projects, the following technical specifications need to be additionally considered in the tender documents:

1. Related to the design phase:

a) *Definition of the structural service life* - The expected structural life of the infrastructure must be specified. This means not only the definition of the years (ex: usually 100 or 120 years for bridges), but also the definition of the meaning of the end of the structural life (ex: level of material degradation). Specifications should also impose the development of a durability design considering the environment conditions and the definition of material properties, showing that the structural life will be achieved.

b) *Definition of functional service life* – The functional capacity of the infrastructure (ex: maximum volume of traffic) should be specified, defining the functional service life. Based on these elements and on the expected traffic evolution the designer will adopt an architecture (ex: number of lanes in a bridge) that will support the expected level of functionality during the functional life. This life may be

smaller than the structural life, meaning that a functional upgrading (ex: widening of the road, building a new bridge) may be needed after some time, what should be analysed in the proposals;
c) *Definition of structural actions* – Design code actions are usually defined for current structures with expected life of around 50 years. For important structures it must be specified that action values have to be updated for the specified service life (ex: increase seism and wind values) and special actions may also be considered (ex: heavy load trucks, fire accidents), achieving an increased reliability of the structure.

2. Related to the construction phase;
a) *Definition of structural monitoring* – Specifications should impose the implementation of monitoring equipment to control the structural behaviour during all the construction phases (ex: evolution of structure and material characteristics) and of final control tests at the end of construction.
b) *Definition of durability monitoring* – Control of initial durability properties of materials in lab and in situ, should also be imposed, to check the specified structural service life.
c) *Construction procedures* – imposition of the implementation of a quality control system where all the major anomalies and correction procedures are previously defined are also the key stone of the construction quality.

3. Related to Operation and Maintenance
3.1 Economical aspects
a) *Definition of the traffic measurement control* – As the concession time and financing of the infrastructure may depend on the functional volume (ex: traffic) it is necessary to have, during concession, an independent control of this volume by the authorities. The definition of this independent system must be specified from the tender phase.

3.2 Technical aspects
a) *Definition of the monitoring plan* – Specifications must impose the development of monitoring plans for structural behaviour and durability to control the behaviour of the infrastructure during the service life.
b) *Definition of the maintenance / repair plan* – The implementation of a maintenance plan defining the inspection methodology, the levels of degradation and the associated maintenance/repair procedures, must also be specified.
c) Definition of the reception conditions at the end of the concession – The accepted levels of deterioration for the infrastructure at the end of concession must also be specified at tender. This is usually done based on the maintenance plan, and imposing an additional period (5 - 10 years) after the concession end, without major repair costs.

CASE STUDY – THE VASCO DA GAMA BRIDGE

The Bridge

In 1995, the 30 years old Lisbon suspension bridge was the only existing fixed crossing over the Tagus River in Lisbon. The high increase in road traffic, saturated the 2x2 lanes of the existing bridge, what led to the government decision of building a 2nd crossing, the Vasco da Gama Bridge. This project was envisaged within a BOT financial solution and a special government office (GATTEL) was created to prepare the tender, control the design phase, perform the follow up of the construction and keep the control of operation and maintenance during service life.

An international tender, including a special set of technical specifications, aiming to achieve quality during service life, was prepared for the new bridge design, construction, maintenance and operation (with toll payment during the concession period), after which the bridge operation will be transferred back to the Portuguese Government. The tender proposals were financially evaluated based on the toll levels and on the total volume of vehicles expected during the concession period, solution that led to lower financial risks, better evaluation of the investment and a variable concession period (around 30 years), function of the traffic evolution. The tender was won by an international consortium LUSOPONTE which after finishing the construction of the bridge in 1998, is presently performing its operation and maintenance.

The Vasco da Gama Bridge consists of a 12km crossing of the Tagus River in Lisbon, being one of the longest bridges in the world. The bridge is located in the mouth of the Tagus River which is a sea type salty environment, subjected to tides and waves, in a high seismic zone and subjected to ocean winds. The crossing is composed of several substructures, named sequentially as: North Viaduct, Expo Viaduct, Main Bridge, Central Viaduct and South Viaduct (Branco 1999). The Main bridge is located close to the North embankment, over the main navigational channel, and presents a cable stayed solution with 420m central span (Fig.1).

Fig.1 – Vasco da Gama Bridge

Traffic and Deck Width – The Functional Life

The bridge functional life is mainly associated with the traffic volume that it can support with the associated design speed (120km/h). Function of the expected traffic evolution, the tender specifications defined a deck width (30m) allowing for an initial period with 2x3 lanes and a large shoulder. When this solution begins to show functional obsolescence (traffic saturation value) the existing width allows for the implementation of 2x4 lanes, with a smaller shoulder. This is an easy upgrading solution, when envisaged from the tender phase.

Based on traffic predictions this solution allows a good functional level during the LUSOPONTE exploitation period and based on a monitoring of the real traffic evolution a decision on the construction of a 3rd crossing will be defined in the future, keeping the maximum traffic level in Vasco da Gama Bridge for the remaining structural life.

Structural Service Life and Durability

The bridge is located in the mouth of the Tagus River which is a sea type salty environment. The tender specifications imposed a structural service life of 120 years for the bridge. For this service life it was also imposed, in the specifications, that no corrosion initiation begins in concrete main reinforcing bars and no section reduction occurs in steel structural elements, considering current maintenance procedures. This imposition was theoretically too conservative, but the variability of the environment factors and of the present existing simulation models led to this option.

With this imposition, the global service life is expected to be achieved in most of the construction elements, namely the structural ones, with minor maintenance costs. Of course several other components of the bridge will have shorter service lives and will have to be substituted during the 120 years within the maintenance plan.

All these aspects are fundamental for the durability of the bridge and the implementation of the above tender specifications, led, in practice, to the following measures during design:

a)Definition of special geometries and materials - This was performed in terms structural safety and of physical deterioration based on local environment conditions and using mathematical models for concrete deterioration (chlorides). In steel structures an additional steel thickness was considered to take into account the corrosion rates estimated, what was important namely for the steel piles length located in the inter-tidal zone.

b) Design with flexibility - The components that will need repair or replacement during the service life were conceived to allow that their replacement/repair will be performed with minor effects on the bridge operation. This was analysed namely for the bearings and dumpers, expansion joints, stay cables, external prestress cables, etc.

c) Definition of a durability monitoring system - A plan with periodic in situ measurements and testing of samples was defined at design stage, to confirm, during construction and service life, the deterioration rates assumed in design.

Structural Service Life and Safety

For service lives different from 50 years, the characteristic values of code actions need to be changed. For the Vasco da Gama bridge the basic design actions were defined considering the Eurocodes 1 (bridge actions) and 8 (seismic design), but they were adapted for the tender specifications to consider a 120 years service life (Branco 2000). These changes led to some special studies here referred.

Environment thermal actions were adapted considering specific studies to define the gradient temperatures, as a function of the bridge geometry and environment conditions, obtained from a statistical analysis of temperature and solar radiation at the bridge location.

Wind actions, defined for the service life, imposed wind tunnel tests to check the deck stability for 250km/h wind speeds. The study of dynamic behaviour of the deck under wind gusts was also imposed. The study of wind vibration of cable stays and the adoption of dampers was also considered.

The adaptation of the seismic actions for the service life led to the use of seismic dampers in the main bridge (Fig.2). Due to high seismic actions, besides the ultimate limit state, it was considered a special "trafficability limit state" for a reduced action (75%) where damages allow conditioned traffic circulation. This was controlled mainly by maximum joint opening or pavement discontinuities.

Fig. 2 – Seismic dampers at main bridge

Construction Procedures

During the construction stage a good quality control is the best way to obtain a high level of structural safety and durability during the planned service life. The tender specifications imposed that construction quality control management should be performed by a quality team independent from the contractor. Their activities were also complemented by periodical checking by the bridge authorities.

Besides the current construction procedures, the following main activities were also imposed at the tender specifications to achieve construction quality and guarantee the defined service life.

a) Initial characterization of materials properties - Before any construction begins, the contractor had to study the concrete compositions to achieve the mechanical and durability characteristics defined in design. This is particularly important because durability tests take time to provide results and if they are not performed in advance, the construction had to undergo some delays (ex: for the study of chloride attack, durability tests were defined as initial references to check the concrete characteristics).

Besides these initial studies, a control was also specified at the reception of all the materials, and in particular for the structural ones, whose composition was periodically checked with mechanical and durability tests to guarantee their compliance.

b) In-situ control of properties – Tender also specified the implementation of in-situ measurements (after application in the structure) of the mechanical and durability characteristics of the materials, to guarantee the technical specifications. This quality control is one of the most important activities and was imposed in a systematic way during all the construction stage. In fact the durability and mechanical characteristics of materials, in situ, are always different from the ones obtained from lab samples and this correlation had to be achieved to have a good simulation of the service life.

c) Construction technology **–** The control of the construction methods was also specified at tender, imposing that they were studied, approved by authority, and implemented to guarantee the best procedures in terms of achieving good quality for the materials and structure. This was complemented with the quality control system where all the major anomalies and correction procedures were previously defined.

d) Reception load test – Load tests were also specified to be implemented at the end of construction. The analysis of the bridge performance, under these tests, is very important to check the models that have been used at design and to define a reference state that can be used along the service life. The tests are performed in the bridge under static loads allowing for the determination of the static behaviour (deflections and strains) of the main spans along the crossing. The dynamic tests were also imposed to obtain the dynamic characteristics of the bridge and of the forces in the stays.

Operation and Maintenance

The tender specified that, since the opening of the bridge, a structural monitoring plan, a durability monitoring plan and an inspection and maintenance plan should be implemented to control the evolution of the main characteristics of the bridge.

a) Structural monitoring **-** The structural monitoring plan was imposed to analyse some of the main parameters that control the structural behaviour of the bridge during its life. It considers the automatic measurement of displacements, rotations, strains, structural temperatures and vibrations in some pre-defined sections. The seismic accelerations on the soil are also monitored.

The structural measurements are complemented with environment measurements (air temperature, humidity, rain fall, visibility and wind speed and direction). These measurements are associated with an action plan where, function of the measured values, pre-defined actions are defined, allowing quick decisions in the case of an accident like a seism or strong wind. All these values are on line monitored and results are periodically analysed by designers, or when predefined levels are over passed.

b) Durability monitoring **-** The durability monitoring imposes a plan that defines periodic testing of material sample. The corresponding durability values are then used to reanalyze the design estimation of the service life. If deterioration is higher than previewed at design, repair measures are implemented. The tests are, in average performed, at 0.5, 1, 2, 5, and all 5 years, after the opening.

Related to concrete elements the tests consider depth of carbonation, chloride path, diffusion coefficient, permeability, porosity and electrical potential. Related to steel elements corrosion (steel piles) the steel thickness is also monitored with periodic measurements.

c) Inspection and Maintenance Plan **-** The imposed inspection and maintenance plan defines all the inspection points, the periodicity of inspections, eventual anomalies to be detected and maintenance procedures. These activities are essentially based on a visual inspection complemented with simple measurements. Particular situations of this plan were already specified from the tender phase:

c.1) Scour - Periodically the depth of the river bed is measured close to each pier. In the navigation channels several points are obtained to draw the river bed plan. This allows the checking of the evolution of scour problems close to the piers and if an important evolution is detected a rock scour protection is pre-defined. This is important because the present theoretical models have very low precision.

c.2) Cables retention - Due to the time dependent variation of the material properties (namely creep of the deck) the retention of the cables of the main bridge was pre-defined. This operation envisaged from tender, considered the following steps: a pre-measurement of the deck profile and of the cables tension (by dynamic behaviour); and a numerical analysis to compute the new tensions to be implemented to obtain the ideal profile.

c.3) Drainage system cleaning - A deficient drainage may be the cause of important deteriorations. To prevent this, the cleaning of the road and drainage pipes was specified to be performed periodically. Due to environment restrictions it was also specified that the drainage water from the South Viaduct should be collected in water treatment facilities.

d) Bridge quality at the end of concession – This is a very important issue as high costs may be involved in the rehabilitation of the bridge at the end of the concession. To prevent this it was specified at the tender phase that the degradation level of the bridge, at the end of the concession, will be evaluated and it must be according to the design previsions. If lower levels are found, repair measures will be implemented according to the maintenance/repair plan, paid by the concessionaire, to achieve a period of at least 5 years without major repair costs.

CONCLUSIONS

In this paper, the technical main aspects that must be considered in the tender specifications of a BOT project, to achieve quality, were presented, illustrated with the case study of the Vasco da Gama Bridge. These aspects included the discussion of the service life, its implications on safety and durability, the definition of the construction quality procedures, the monitoring of the operation, the implementation of the maintenance plan and the reception conditions at the end of the concession.

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Quality Systems and the Competitiveness of the Civil Construction Companies

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Abstract
The competitive demands of a global economy consist of an important aspect to reach the Total Quality. The present work has as objective to study one of the elements that influence the competitiveness in the subsection of building construction: the use of a quality system to help the construction processes management. Five managers of five civil construction companies were interviewed and they give their own analyses about the process of quality management using the quality system called Qualification System for Construction Companies – SIQ at their companies. After that, the researcher elaborated a ranking with these companies according to the competitive advantage of each one through the total quality aspect. During the elaboration of the questionnaires, it was used the Study of the Competitiveness of the Brazilian Industry - ECIB, where it takes into consideration the internal and external quality aspects of the company in a continuous search for improvement. The application of this proposal at companies of the construction sector will allow the analysis of how the application of a quality system or quality philosophy happen in the construction companies and its consequences in the competitiveness of the construction subsection in a general view.

Keywords
Civil construction, housing, competitiveness, quality system

INTRODUCTION

The perspectives of research on the subject "quality and innovation" according to Gautier [1993], has as main point that the industrial innovation is an activity that must be measurable, to justify it's financing. The innovation must be supported on one global politics of the company to follow in the direction of a process as factor of its competitiveness and surviving. Relative subjects to the quality and enterprise competitiveness, quality in the civil construction as total satisfaction of the internal and external customers are in focus currently. In a practical way, the executives are convincing themselves that for the surviving of the company and to maintain it competitive in the market with a good performance, their external and internal customers must remain satisfied. Nowadays, the market is more competitive and the customers are more demanding. The companies need to look ahead of this scene. Due to this fact, the sector of the civil construction following the example of other industries, is adjusting to it the new enterprise strategies that consider the quality of its product, its processes and the organizations.

PAPER´S PURPOSE

The main purpose of this paper is to identify how the implantation of a total quality system in construction companies influences the competitiveness in the Industry of the civil construction, especially in the sector of buildings construction, according to their internal staff. And, as specific purposes there is the analyses of the effect of a total quality system adopted for the civil construction companies in the city of São Luis - MA - Brazil and the diagnosis of the building construction industry competitiveness through the analysis of its internal structured factors to the company presented at the Study of the Competitiveness of Brazilian Industry – ECIB (Coutinho e Ferraz, 1995).

RESEARCH METHODOLOGY

The research started by reviewing the relevant literature on the field (Total quality and competitiveness). It was followed by exploratory observations, where the researcher used the literature facts to realize *in loco* some aspects of the company reality in a way to give a diagnosis of the company. The structured interview was carried through with the main executive of the company, or civil engineers responsible for the construction. The research took place in small companies (the ones that have less than 100 employees) and that were in the highest level of quality according the direction of SIC (Qualification System for Construction Companies). The questionnaire used during the interview was prepared according to the ECIB pattern, it was related to the internal factors to the company, determinative of the competitiveness, adapted from the authors according structural conditions of the civil construction industry in São Luis-MA-Brazil. The application of the questionnaire occurred in the months of January and February of 2005 and its analyses happened in February, March and April of the same year. After the data analyses, demonstrative graphs of indexes of actions for the quality management process and performance indexes for the quality management process of the company were prepared. It was also created a kind of ranking of the companies according to its position in the market.

THE ROLE OF A QUALITY PROGRAM AND SYSTEM IN THE COMPANY

The companies look for quality programs and new technologies to improve their work techniques and this improvement should be reached by the companies during the implantation process of quality management that gives greater competitiveness to them, guaranteeing its survival in the market (ISRAELIAN et al, 2001). According to POSSAS (1997), technology affects quality and prices, acting indirectly on the competitiveness process. More and more, the competitiveness is associated mainly with the differentiation of the products through the technological innovation and not with prices and costs.

In historical terms, the quality always developed connected to the industry and it could be classified according to four distinct stages: quality inspection, quality statistical control, quality warranty and total quality management. In the stage of total quality, the quality has been seen as a competition opportunity (SOUZA et al, 1995). In short, according to SOUZA et al (1995), to have project quality control it is necessary to guarantee definitive patterns, which act as reference standards to implement the control. However, many factors must be observed and be taken into consideration during the concurrent development of quality systems at company level in order to achieve an acceptable quality level according to standards of programs as the ISO, PBQP-h, Qualihab, for example.

The companies are interested to apply quality actions but they need the return on investment, it means, effectiveness of the system. Effectiveness is defined in ISO 9000 as "the extent to which planned activities are realized and planned results achieved". To this definition, Deming adds the famous cycle, which adds the Act phase to the Plan, Do and Check phases that are inherent in the definition of effectiveness. Although, the experience of companies demonstrates that a quality assurance system alone is not enough to achieve continuous improvement, and it is also necessary to incorporate a management system based on the Total Quality Management principles (OLIVEIRA & ESCRIVÃO FILHO, 2001, EQF, 2002).

RESEARCH ON QUALITY IN CIVIL CONSTRUCTION

The process of implementation of a quality program requires change of cultural standards that are usually resistant on the part of some sectors of the organization. Bresnen et al., 2003, showed that fact through a research carried out in the United Kingdom, where the new factors that affect the implementation of a management method and resultant implications of the improvement of the management of the knowledge of the contractors and the capacity of organizational learning had been examined in a practical way. It was verified that for the understanding of a change process in a company, it is very important an internal politics that require cultural changes, and dynamics in the organization that help the development and implementation of new ways of knowledge.

Each organization has its proper culture, created unconsciously based on the company founders or administrators values. These managers must understand the organizational culture of their companies if they really want to change it (JEFFRIES et al., 2003). Face to this fact, it is very important the commitment of the high management with the program in order to stimulate the practice of new principles until the desired changes become irreversible and it is not demanded, necessarily, the use of new tools (Kretzer et al., 1996). The search for quality improvement in the construction needs a progressive methodology, not always of great size. It means, for instance, to develop, to rationalize, to eliminate small losses, and to produce small benefits. In the implantation of this process some practical rules are suggested: the respect to people values and beliefs; the total satisfaction with the gain of small benefits is not allowed (it is necessary a strategic planning to search important benefits for the organization) and the trust between the different parties involved in the construction process is fundamental for the success of quality initiatives.

Despite the use of the Management Integrated Systems for some companies in Brazil and the importance given to the project process conception in the civil construction, there are not detailed studies about the incompatibilities and difficulties to adapt the current models of quality management systems at companies that work with projects, therefore it is important for a good performance of the Integrated System of Management, the organization must happen since the phase of the project conception (OLIVEIRA and MELHADO, 2003).

PICCHI [1997], says that introducing a quality concept requires considerable efforts in an industry as traditional as the construction industry. He also shows at his work the benefits of the use of internal norms from a system applied in construction companies who develop programs aiming at the improvement of the quality and productivity. These companies will be able to customize and to democratize the knowledge, to register its "know-how", to establish routines that become the processes steadiest and to permit a more rational use of the resources. That way, it is easier to define quality standards, to develop and improve the technical level of the staff and to implement quality and productivity programs. Some difficulties also are detected in the process of implantation of a system of norms in a construction company. Considering these difficulties, it is clear why many programs of quality implementation are not successful. Thus, some researchers have been studying the causes of failure of the quality programs implementation at the organizations. The causes of failure in the implementation of Quality Programs raised by CROSBY (1993), TOLOVI Jr (1994), WOOD Jr & URDAN (1996), VALLE (1995), TATIKONDA & TATIKONDA (1996), BACKES (1998) and TAMIMI and SEBASTIANELLI (1998) are displayed in Table 1 as it is described in the work of OLIVEIRA & ESCRIVÃO FILHO, 2001.

Table 1 Causes of Quality programs failure

Failure causes	**Authors**						
	1	**2**	**3**	**4**	**5**	**6**	**7**
There is no financing measures to quality	X				X		X
Lack of focuses on customers	X				X		X
Inadequate training	X	X		X	X		X
Lack of high staff commitment	X	X	X	X	X	X	X
Lack of commitment of the hierarchic levels		X	X				
Lack of technical support		X					
Anxiety for results		X					
Creation of internal parallel bureaucracy			X		X		
Image Focus and not on the results			X				
Internal process focus and not on the critical ones			X				
Interests and power conflicts			X				
Resistance to changes			X	X		X	X
Identify guiltier to the problems				X			
Not continuation of the program				X			
Lack of communication				X			
Failure at the department's coordination				X		X	
Planning missing	X				X		X
Failure in the organizational structure					X		
Lack or bad use of indexes					X		
The workman force is not recognized		X	X		X		X
Failure at the finances control					X		
There is no benchmarking							X
Lack of authority of the workman force at the implementation of quality actions							X

Legend about authors
1- CROSBY 2- TOLOVI JR. 3- WOOD & URDAN 4- VALLE
5- TATIKONDA & TATIKONDA 6- BACKES 7- TAMIMI E SEBASTIANELLI

INDUSTRIAL COMPETITIVENESS

According to his job, MacFetridge, 1995, says that competitiveness means different things to different people and that is helpful to consider competitiveness at three different levels of aggregation: the firm; the industry or groups of industries; and the nation.

At each level of aggregation, there are different measures, or indicators, of competitiveness. They vary in what they imply about the present and future economic success or well-being of a firm, industry or nation. Some concepts of competitiveness are applicable at one level of aggregation but not at another.

To be competitive and generate profits superior to those of their competitors is the central aim of almost all firms.

A company that is unable to achieve competitive advantage face to its rivals will not be able to prosper and grow (PORTER, 1989). The concept of competitiveness can be defined as *doing things better and/or doing better things* than your rivals. It deals with everything from productivity in production to the ability to innovate and the strength of marketing functions. But only looking inside the own firm in this search for the sources of competitiveness may not always be enough. Building relationships in networks and paying attention to the local market is growing in importance. As a consequence of this, concepts such as learning regions, industrial districts, innovation systems and industry clusters has been given much attention as a way of understanding and explaining regional growth and firm competitiveness over the last decades.

In the Study of the Competitiveness of the Brazilian Industry, Coutinho and Ferraz (1995) affirm that in 1993 the competitiveness level was being extended specially for the level of customers' requirement. Orssatto (2002) affirms that in a relatively steady environment, a company can grow and survive without explicit a competitive strategy. However, in a changeable environment and with high competitiveness, the company that does not shows its competitive strategies is faded to be unfair with its departments, being, thus, vulnerable to the external market.

In the ECIB model, the competitive performance of a company, industry or country is conditional upon a set of structural factors that can be subdivided in internal factors to the company, industrial factors and systemic factors.

In the research, the internal factors to the company had been used. And, for each item of the model it was stipulated some items for the quality management process as shown below:

1) Strategy and management **-** measured of performance and vision of the quality
2) Qualification for innovation **-** evaluation of the environment impact and orientation to the customer
3) Productive Qualification – processes, suppliers and subcontractors standardization.
4) Human resources **-** training and education and participation of the employees.

The internal factors to the company are classified by the study as the ones that are under the power of decision of the company, and are used to get competitive differentials from the competitors. The structural factors are not totally controlled by the company, however they are under its influence and they characterize the competitive environment around the company. These factors are related: to the characteristics of the market; configuration of the industry where the company acts; to the competition. The systemic factors of the competitiveness are defined as the external factors of the organization, however they affect the characteristics of the competitive environment and could have great importance to competitive advantages that the organizations of a country have, according to the international market.

PRACTICAL INQUIRY AND DATA COLLECTION

Initially it was carried out an individual analysis of the company and workmanship. With the data gotten *in loco* it was possible to identify the general state of quality at the company. During the field research the quality in the company was classified in five levels: 1(none), 2 (bad), 3 (regular), 4 (good) and 5 (Excellent). After the survey of the situation of the company faced to quality, it was carried out the structured interviews with the top management and civil engineers from five

companies in the city of São Luis-Ma-Brazil in order to find out how the company staff auto-evaluate their quality management into the aspects of SIQ (the quality system adopted).
As a limitation of the work, only the internal factors of the company were analyzed.

DATA ORGANIZATION AND ANALYSIS

This paper selected some actions and strategies undertaken by the companies studied, taking into consideration some aspects of the quality system SIC and how these aspects influenced the internal factors described at the ECIB methodology, to elaborate the questionnaire used at the research.
After the collection of the data in the company, it was analyzed following the order below:
First, some problems related to quality proceedings were identified in each company, as showed in Table 2. During the interviews the staff gave their opinions about the solutions of these problems in order to follow the SIQ lines of direction.
Then, considering the SIQ lines of direction that influence the ECIB aspects, the staff of the company gave their opinion about the level of effectiveness of the SIQ lines of direction to solve problems related to quality management. This effectiveness was punctuated according to five indexes:

- 1 – the aspect was not used or it did not show effect at the company and its problems;
- 2 – the aspect was used and showed bad effects at the company and its problems;
- 3 – the aspect was used and showed regular effects at the company and its problems;
- 4 – the aspect was used and showed good effects at the company and solved its problems;
- 5 – the aspect was used and showed excellent effects at the company and solved its problems.

Table 2. Identified problems at companies in the research related to quality proceedings.

Problems	**Companies**				
	A	**B**	**C**	**D**	**E**
Lack of time of employees		X			X
Lack of consultant coordination				X	X
Internal resistance		X			
Difficult use of technical tools				X	X
There is not a diagnosis			X	X	
The staff is not involved					X
The employees are not involved		X			
The suppliers are not involved	X	X	X	X	X
Lack of planning	X	X	X	X	X
The company does not know the client’s preferences	X			X	X
There is not the Knowledge about the market		X	X	X	X
No responsibility for the quality					X

The application of the methodology happened with the participation of everybody from the company, from the high administration to the operators passing through the quality coordinator. They developed an auto-evaluation through the fulfilling of the questionnaire. The research process happened, basically in four stages, described as follow:

1) the administration of the company auto-evaluated it and gave a grade from 1 to 5 according to the indexes of effectiveness showed above. They filled out a simple

questionnaire that listed the quality aspects that influence the internal factors of competitiveness.
2) the researcher visited the companies evaluated, with the objective to verify the reality according to the questionnaires answers.
3) the evaluation was discussed with the administration of the company and the researcher made some adjustments of the initials punctuations given in the questionnaire in accordance with the reality of the company.
4) According to the collected data a report was elaborated and it was presented in a meeting at each company. The report showed indexes of actions and performance indexes for the quality management process.

The questionnaire was divided as the following: questions about the vision of the quality, standardization of the processes, quality of the raw-materials (an index was established at this point); subcontractors´ delivered product quality (another index); customers claim; the internal defects and suppliers and subcontractors level (another index). As it was described before, the analyses were done using the punctuation from 1 to 5 and the questions mentioned actions indexes (techniques) and performance indexes. The results of the analysis are shown at Figures 2 and 3 and they are the representation of the quality process management using the SIQ methodology. It is important to say that the companies are placed in a decreasing form according to the punctuations gotten in each aspect. And it is also important to say that this order confirms the level of competitiveness of the firm based on the ECIB methodology.

Company A	5	5	4	1	4	5	5	4
Company C	5	4	4	1	4	5	4	3
Company B	4	4	3	1	3	4	4	3
Company E	4	4	3	1	3	4	4	3
Company D	4	4	3	1	3	4	4	3
	Training and education	Performance indexes	Process Standardization	Environment impact analyses	Suppliers and subcontractors	Employees participation	Quality view	Client orientation

Fig. 2 Indexes of actions for the quality management process.

Company A	3	4	4	4	4
Company C	2	4	3	4	3
Company B	1	4	2	4	3
Company E	1	4	2	4	3
Company D	1	4	2	4	3
	Internal problems	Customers satisfaction	Customers blames	Materials quality	Quality of the products given by the subcontractors

Fig. 3 Performance indexes for the quality management process.

CONCLUSIONS

The civil construction is crossing the line between the traditional way of management and new philosophies of production. The existing processes need to be improved in a maximum way before the new processes projects. It is important to point out that in a quality program the goals must be defined and the workforce commitment is inherent factor to the process. A basic requirement for the success of a quality management program is the fact that all people involved into the process

should be aware that will be winners. Leadership and good communication channels are important in order to facilitate a change in company culture and increase quality awareness amongst the staff.
The work had the aim to find out how the implementation of a quality system in construction companies influenced the competitiveness in the construction industry. Through a methodology that allowed the classification of the researched companies according to the level of effectiveness of the fulfillment of the requirements of the SIQ standards and its benefits in several aspects, the companies were evaluated from 1 (the requirement was not used or it did not show effect at the company and its problems) to 5 (the requirements were used and showed excellent effects at the company and solved its problem). The study showed that the effective use of the requirements of a quality management system brought competitive advantages to the companies in order to confirm the strategy chosen for the company in applying a Quality Management System and agree with Porter's [1989], affirmation, 1989, that takes strategy from broad vision to an internally consistent configuration of activities.

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Measurement of Labor Activity Level Toward a Productivity Improvement in Chilean Construction Projects

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Abstract
The construction industry in Chile has been improving its performance during the last 20 years. There have been improvements in the safety of the site, reduced performance time, improvement in materials, and by implementing more technologically advanced equipment. However, labor productivity has been the last concern for the construction companies.

The objective of this Paper is to encourage the necessity of introducing and establishing in Chilean construction companies a simple and inexpensive measurement metrics for labor force activity level. This, in order to establish a basic standard of labor performance and improve the overall productivity of construction projects, thus companies will have a tool to improve their labor productivity as well as productivity changes throughout the construction industry.

This paper also discusses the needs, the difficulties, and offers recommendations for measurement of labor activity level by means of work sampling studies.

Keywords
Work sampling, activity level, labor productivity, construction management.

THE DEFINITION OF THE PRODUCTIVITY MEASUREMENT
Productivity is the ratio between input and output. In general, productivity is the measurement of how well an individual entity uses its resources to produce outputs from inputs [Pmbok, 2000]. Moving beyond this general notion, a glance at the productivity literature and its various applications quickly reveals that there is neither a consensus on meaning nor a universally accepted measure of productivity. Attempts at labor productivity measurement have focused on the individual, the companies, select industrial sectors, and even entire economies.

There are a number of different productivity measures that are commonly used. Choosing between them usually depends on the purpose of the productivity measurement and the availability of data. Productivity measures can be placed into two broad categories:

- **Single factor**, or partial productivity measures (SFP), relate a particular measure of output to a single measure of input, such as labor or capital.
- **Multi-factor**, or total productivity measures (MFP), relate a particular measure of output to a group of inputs, or total inputs used.

Labor productivity, based on gross output, traces the labor requirement per unit of output. It reflects the change in the input coefficient of labor and is useful for the analysis of specific industry labor requirements. Its main advantage as a productivity measure is its ease of measurement and readability; for example, the gross output measure requires only price indexes on gross output. However, since labor productivity is a partial productivity measure, output typically reflects the joint influence of many different factors. A more reliable and uninfluenced approach could be by measuring labor productivity directly through field work rather than using general gross data.

Finally, it is important to remark that these measures help to conclude recommendations and suggestions, based on the statistical analysis of the project activities in order to reveal the sources of inefficiencies. It is also important to state that this empirical tool is not oriented to analyze the performance of a particular worker, but rather to improve the general performance by means of detecting the system's problems.

THE NECESSITY OF MEASURE LABOR PRODUCTIVITY

Why should we care about measuring the efficiency of the workers? Because labor constitutes such a large part of the cost of construction, representing on average 30 to 40% of the total construction costs [Picard, 2004]. Moreover, the quantity of labor required is more susceptible to the influence of construction management than are quantities of either capital or materials.

For many industries, statistics on long-term productivity trends are generally available, particularly in goods-producing sectors like mining and manufacturing. The same cannot be said for the construction industry. This discrepancy is primarily due to the measurement difficulties regarding real inputs and outputs unique to the construction industry. In most countries of South America, the construction industry is criticized as unprogressive, archaic, and conservative. Nevertheless, the construction industry in this continent has made significant strides in recent years in developing safer work sites, shorter construction time lines, and more resilient products and systems that make the environment more productive and efficient.

Due to the increase in training, specialization and productivity of its workforce, Chilean productivity is competing effectively in world markets. However, the Chilean labor productivity still must improve its performance because some research show an efficiency of 41% compared to USA labor productivity [Van Ark and McGuckin, 1999].

The Chilean companies used different performance indicators such as labor productivity (Cost Factors), work sampling measures, resource productivity, etc. The metrics of these indicators are normalized as percent variation in order to compare the improvements [Alarcón and Calderón, 2003]. In spite of this, companies have the perception that manpower in construction is an unsolved problem, with an important cultural and social component, which is not easy to improve by management tools.

To improve the labor productivity the construction companies appeal to use a set of management tools focused in training, leadership, team develop and organizational changes, but these actions are not measured to quantify the new work performance improvement achieved.

Therefore it is necessary that companies have an easy tool as a *work sampling study* to measure their labor activity level and develop a systematic record of this information. This information could be valuable considered as an input for balanced scorecard or any other information technology system.

DESIGN OF WORK SAMPLING STUDY

This management tool, based in single factor productivity, consists of gathering discrete information from a representative crew during random observation. The work activities of the crew are classified into three main categories: direct work, essential contributory work and ineffective work. This information can be used to determine the overall performance of activities and to calculate the productivity of workers.

Next, a basic description of the tool is shown with the objective of introducing main concepts and the general procedures of the sampling measure.

Sample Size

To calculate the number of observations necessary to complete the sample study, the following equation is used:

$$\mathbf{N = K^2 \cdot P \cdot (1 - P)/S^2} \qquad \mathbf{(1)}$$

Where:

N: Number of observations required
K: Number of standard deviations required for a given confidence level
P: Decimal equivalent of the percentage expected in a given category
S: Decimal equivalent of the degree of accuracy

For P it is important to select an expected fraction of time that workers do direct work, usually 1/3, but this fraction may vary depending on the activity analyzed.

Activity Classification

To identify the labor productivity, it is necessary to split the labor performance in small units of work (into Work Breakdown Structure). These units of work are classified in the three groups mentioned to facilitate the analysis:

- *Direct Work (DW)*: Is the process of adding to the unit being constructed. This includes productive actions such as cutting, pouring, installing, compacting, digging, etc.
- *Essential Contributory Work (ECW)*: Are activities that complement the direct work. They are considered ECW because they are not directly related to the activity observed, i.e. picking up tools at the area where the work is taking place, inspecting for proper fit, putting on safety equipment, supervision, planning or instruction, all travel, carrying or handling materials or tools, and walking empty-handed to get materials or tools.
- *Ineffective Work (IW)*: Any other activity observed which is not a contribution, whatsoever to the project and not considered DW or ECW, was labeled IW.

This activity classification defines the type of contribution that workers are doing in relation to the overall objective of the project during the foundation activity. This is an important point to consider, because the overall objective of the measure is calculate the total direct work (TDW). The TDW is defined in the following equation.

$$\mathbf{TDW = a{\cdot}DW + b{\cdot}ECW + c{\cdot}IW} \qquad \textbf{(2)}$$

Where:

- a: Factor for direct work = 1.00[1]
- b: Factor for essential contributory work = 0.25[1]
- c: Factor for ineffective work = 0.00[1]

Is important to remark that in the definition of the task analyzed, some activities can have an important equipment component; therefore the labor would be inefficient for a significant fraction of the time.

Random Times Determination Technique

The classification mentioned above is then assigned to the activities that are being performed in several observations. These observations are taken at random times during set intervals, allowing statistical laws to create a low degree of error. The following equation was used to determine the hour of each observation.

$$\mathbf{H = H_{ini} + X_i{\cdot}(H_{end} - H_{ini})} \qquad \textbf{(3)}$$

Where:

- H: Hour of random observation
- H_{ini}: Starting time for observation period
- H_{end}: Finishing time for observation period
- X_i: Random real number between 0 and 1

To provide reliable and quality data, the gathering process must be oriented in a particular sector of the construction that provides a proper distance for observers, avoiding the interaction with workers. Also, it is important to consider the use of several statistical tools to improve the accuracy of the information, confidence intervals and extrapolation of results.

CHARACTERISTIC THAT MAKE THIS TOOL USEFUL

One of the most important restrictions that construction companies have during their construction performance is the lack of resources and time to develop surveys about their labor productivity. For this reason, they need a quick productivity measurement metric as well as simple, inexpensive and easy to understand.

The sample study achieves these requirements according to the following characteristics:

- The study can be performed in any construction type at any time
- The measures can be performed by people with basic training
- The measures can be carried out with basic recording devices

[1] Referential value, some companies can consider different factors in their activities.

- The measure is made by only a few people and requires only a few samples, and is inexpensive compared to other productivity surveys
- Some results are immediately available for improvement evaluation
- Analyzing the data can be an additional step

The use of this tool will offer valuable information to field management and could be beneficial at several levels: creating an awareness of crew activities, establishing a performance mindset that makes cost and schedule control a daily occurrence, allowing easy evaluation of a task and work conditions and reassigning crew members with evident non-productive time.

Some limitations that should be considered are [Serpell and Venturi, 1997]:
- It does not show the origin of inefficiency
- Does not provide production rates
- It does not provide information of materials or equipments.

Finally, this management tool can be used in combination with others studies to be strengthened, as an example [Serpell and Alarcón 1998]:
- The five minute rating, gathering continuous information from a crew, and used it to determine the overall performance of activities and to calculate the productivity of workers.
- Crew balance chart, analyzing the cyclical activities.
- The micro analysis, a technique used to examine flow diagrams, the crew activity cycle and to make particular observations.
- The macro analysis, a technique employed to observe the construction as a whole and use this information to identify relevant sources of productivity problems.
- Other surveys, oriented to gather objective or subjective information from people involve in the project.

LABOR MEASUREMENT DIFFICULTIES

As Chilean society has grown and changed, its economy has become increasingly more dynamic and complex. As a result, economic measurement and analysis, particularly relating to labor productivity, has become more difficult and complicated [Gunduza and Hanna, 2005].

Accuracy Issues

The main problem of accuracy in this metric involves properly defining units of measurement, evaluating qualitative changes and obtaining reliable data. Labor input, if measured by hours actually worked, is better suited to reflect the changing rate of manpower utilization, but remains an imperfect measure [Edwin, 1999] [OECD, 2001]. Information technology (i.e. scheduling software) may aggravate this measurement error by allowing increased work flexibility and longer effective workdays that are not properly captured by others sources of information.

Measurement difficulties have specifically hampered productivity analysis of the construction industry. There is a general consensus that current construction data does not provide an adequate nor accurate measure of labor productivity. The reason given for not producing adequate measurements of production in the construction industry is the difficulty of measurement given data limitations. As an example, thanks to automations and IT [Navon, 2005] it is possible to know the exact efficiency of a digger (volume/hour or length/minute) that represents close to 10% of the total construction cost, but no information is gathered about manpower that represents close to 40% of the total construction cost.

Cultural Issues

In Chile, around 18 % of the labor force is unionized, and 96% of unionized labor is affiliated with the United Workers Federation (CUT). Therefore, many companies may avoid these surveys because they think that measurers gathering information could be seen as an excessive control rather than a management tool. It is not easy to explain that the tool is not aimed at detecting and firing the workers who are not accomplishing their work. In some South American countries this can be a reason to detonate collective bargaining strikes or other manifestations of dissatisfaction.

There is a belief that labor productivity can not be improved because it is a cultural factor, thus, the companies are not concerned because they included it in their estimations [Serpell and Rodríguez, 2002], without any intention to improve it.

SOME ATTEMPTS IN CHILE

The relevant measures are developed in Chile by few private construction companies, who are not interested in publishing their results. However, some universities and Chilean entities are involved in measuring productivity as a whole (ratio input/output), but few of them focusing in the instability of labor productivity.

The main research of work sampling in Chilean construction had been made by Universidad Católica de Chile [Serpell and Venturi, 1997] and by Dictuc[2] during its consulting experience, both have been making attempts at analyzing productivity aspects from within companies (i.e. construction workers, mining equipment operators, data entry workers, harbor laborers) developing new techniques to analyze the productivity and the labor performance [Fresard, 2003].

In the private sector, the service CALIBRE [León, 2004] is one of the most significant developments of productivity measure, which is provided by Technological Development Corporation (CDT), but remain the focus in the overall productivity rather than the particularities of the manpower performance in the site.

THE NEXT CHALLENGE

To go forward with the establishment in Chile of a massive labor activity level measurement by construction companies, it is necessary to undertake a sequence of studies oriented to show the effectiveness of the tool by means of case studies, success examples of improvement and Total Quality Management [Serpell *et al*, 2002]

Some initial studies should focus on analyzing and perhaps redefining the unique characteristics of the diverse manpower and of the construction process, establishing appropriate measurement conditions and restrictions.

Future research should focus on automating the analysis process after creation of the crew measurement. The automation issue is well suited to a mathematical optimization methodology.

[2] Technological and Scientific Research Direction of the Catholic University of Chile.

Other research in optimization of similar processes has proven successful [Son and Skibniewski, 1999]. Future studies should also pay particular attention to recent industry innovations, such as increased offsite fabrication, new materials and improved communications, and an attempt to estimate the impact of these innovations on labor productivity. As an example, the University of Wisconsin-Madison is developing several labor productivity measurements with the aid of web cameras installed at construction sites to gather information on real time about workers.

Some questions may be posed to be answered through this fundamental on-site research and development:

- Is there any relation between labor activity level and overall labor productivity?
- Is it true that productivity of construction crews is substandard?
- What are acceptable standards?
- How beneficial (incidence in total cost) will the improvement of the labor productivity be?
- What are the contributing factors (related to construction management) which have an influence on labor productivity?

In spite of the difficulties that the labor productivity measure could raise, we believe that in Chile there should be developed, published and monitored measures of labor activity levels and labor productivity that the construction industry or other sectors with the same labor component could use to evaluate and improve their practices. This information could be concentrated by sharing the companies' information or by a national survey funded by the government or related entities (Central Bank, Chilean Construction Chamber, Construction Institute).

CONCLUSIONS

"*Before productivity can be improved, it must first be measured*", according to this statement, this article introduced construction labor activity improvement studies by means of data collection and analysis techniques as a quick, simple, inexpensive and easy-to-understand tool for developing countries' construction companies, particularly posed to be used in Chile as a basic standard of labor measure.

We understand that there are many items that contractors must consider when managing a project; however, analysis tools such as sampling measures combined with other management tools, have the potential of significant savings of both resources and time when used on a project. Work performance improvements that may seem obvious when shown in a chart format may be entirely overlooked in the busy nature of a contemporary complex construction project. By taking the time to develop and use these tools on critical activities, field supervisors and managers may experience significant benefits.

It is important that companies understand that measures provided by external entities can provide more reliable information about labor productivity than if the information is gathered internally, because the companies that measure their own productivity tend to have a skewed vision when they analyze the results. Also, the internal data would not be analyzed because the lack of people dedicated exclusively to this purpose.

We encourage the development of these measurements in the construction industry in Chile; however, we think that it would be important to extend the idea to other industry sectors with a

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relevant labor component. Also, it would be useful to extend the metrics of labor force to other South American countries with similar economic challenges and increasing needs for facilities.

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Chilean Engineering Exports and Free Trade

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Abstract
This paper aims to present how Chilean engineering has developed in the last 40 years and how exports have been increasing, and to explore the difficulties engineering faces for exports and how free-trade-agreements may influence these exports. Engineering activity is key for the development of construction projects and has an important multiplying effect. Chilean engineering is a consolidated services industry with a strong potential for exports, which still represents a small percentage of its activity. Free-trade-agreements are recognizing the need to eliminate factors that hamper international engineering trade. These efforts must be deepened through a greater participation of the private sector. This paper reports an investigation was done on the development of engineering services in Chile since the late fifties, as well as its export history. The investigation made major findings regarding limitations associated with the process of improving competitive advantage in engineering in a developing country like Chile. The paper also presents the experience of Chilean Engineering Associations with free-trade-agreements. It concludes that the findings should be brought to the attention to the main players in the construction industry and at governmental levels of the importance of engineering as a key factor for an increasing presence of all industries related to investment projects in a globalizing world and how free-trade-agreements can help increase engineering trade.

Keywords
Engineering, exports, chilean, Free-Trade agreements, competitiveness

A BRIEF HISTORY OF ENGINEERING SERVICES IN CHILE

Consulting engineering was practically inexistent in Chile until the late fifties.

In the early sixties engineering companies started to be founded as humble operations consisting of a few engineers and designers, specialized in a particular discipline. Consulting engineering was at this time embryonic in Chile, and most engineering for industrial projects was hired from abroad.

The late sixties were key for Chilean industry as well as for consulting engineering firms. Political changes came about when the copper industry became nationalized, which in turn led to new policies, one of which was to stimulate increased participation of local engineering in order to take advantage of low local engineering fees, that varied between 1/3 and 1/6 of the foreign ones. This cost difference was maintained throughout the years and has been of great importance to the development of local engineering. Additionally local engineering has advantages related to a better consideration of local construction capabilities and codes, as well as of improving competitive advantages of local fabrication of equipments. Usually engineering companies adopted the policy of establishing alliances with other important local or their foreign counterparts so as to get access to multidisciplinary, complex projects. As a result, they gained an important participation in the main copper and steel industry expansions and in the new investments that were made in the pulp and paper, and the petrochemical fields during the 1960s and the beginning of the 1970s.

The increased complexity of the tasks local engineering was performing for the state-owned copper industry and the growing private industry resulted in the creation of multidisciplinary engineering companies with construction management capabilities in the early eighties. It was quite typical as well, that these firms entered into cooperation agreements with large international engineering companies that would usually be in charge of process design and overall management of large investment projects.

Project services, such as scheduling, estimating and purchasing were developed in the mid-1980s, and resulted in full management and Engineering, Procurement and Construction Management (EPCM) capabilities since 1988. In the mid-1980s also the first Chilean process engineering firms were created, thus initiating activities in conceptual and basic engineering until then performed only by foreign companies. This diversification paved the way for Chilean engineering participation in a major part of the big projects carried out in Chile during the second half of the 1980s. Examples are the CODELCO Copper Flash Smelter, the world's largest at the time, and the CODELCO Copper Solvent extraction/electro winning (SX/EW) Plant, that was constructed to process solutions from the largest dump leach pile in the world. These two projects represented a total of 445.000 engineering man-hours, of which 93% were performed by Chilean engineering. Additionally, during the late 1980s, local engineering firms were highly involved in three bleached kraft pulp mill projects that represented more than 2.6 billion USD invested and over two million engineering man-hours for local firms.

Chilean engineering participation in terms of man-hours had grown from 20% in the early seventies to 90% in the mid eighties to almost 100% in the late eighties. Companies like Exxon's owned Disputada de Las Condes claimed in 1992 a 96,5% of the engineering of their large investment projects had been done by local engineering. Later in the nineties the country entered into a fast growing process, yearly foreign investment increased several times, the engineering market exploded, an important number of international engineering and construction companies established operations in Chile and Chilean engineering companies increased their capacity by 30% in just a few years, reaching a peak of 12 million man-hours/year in 1996.

Present capacity in terms of man-hours is similar to the one existing in the late nineties.

Expertise of local engineering companies is found mainly in areas related to the large investment projects of the nineties, namely mining, energy, pulp and paper and forestry, fishing, agriculture and industry. In particular, world class expertise is found in mining planning, design and in hydrometallurgical and pirometallurgical processes for copper and non metallic minerals, such as lithium, boron, iodine, sodium and nitrates.

THE EXPORT HISTORY OF THE CHILEAN CONSULTING ENGINEERING INDUSTRY

Considering the extensive cooperation Chilean engineering firms have been involved with foreign partners, and their improved competitiveness in the home market, their foreign market experience is surprisingly limited. An organized attempt to gain access to the international market was made at the beginning of the 1970s, partly provoked by the political instability then existing in Chile, through the creation of the organization CLAID, Consultores Latinoamericanos para la Ingeniería y el Desarrollo. The organization consisted of one representative for each one of the Andean countries. Chilean representative was INDEC, an association of several Chilean engineering firms. The activities within CLAID resulted in some exports in the middle of the 1970s from Chile to Venezuela, Ecuador and Bolivia, but in 1979 the organization ceased to exist due to the withdrawal of Chile from the Corporación Andina de Fomento and high local demand for engineering services.

In the nineties several Chilean engineering firms were forced to promote their services abroad in order to qualify for projects at the highly competitive home market. The reason for this was the great influence that new foreign investors in mining had in the engineering market. The decision-making of these investors normally took place at their home offices, where little knowledge, and less confidence in local engineering were found. Several attempts were made to initiate exports as subcontractor of internationally well-reputed engineering companies. However, when the moment of deciding how to organize the work within the project arrived, Chilean engineering was always excluded, notwithstanding its cost advantages.

At the beginning of the 1990s several Chilean Engineering Firms decided to make new, and serious attempts to internationalize their businesses. Although the focus has so far been on the Latin American market, engineering exports now include other economies such as the USA, Africa, Europe and Thailand. Among the results achieved and just as an example it can be mentioned an EPCM contract for a copper smelter revamp in Mexico, won in competition with four Northamerican engineering companies. Exports, as recorded by the Chilean Association of Consulting Engineering Companies (AIC), have grown from 2.2 million USD in 1995 to 12.8 million USD in 2003 [(1)].

FACTORS FOSTERING AND HAMPERING INCREASED EXPORTS

Chilean engineering possesses various qualities and advantages that could be successfully exploited in the foreign market, including the following:

1 Chile's image of a country that has been able to find its own way to development and that has managed itself to carry through of a number of technologically advanced projects.
2 The awareness that local engineering firms have played an increasingly important role in these projects.
3 The existence in Chile of unique know-how, adapted to the specific conditions present in developing countries. One example is locally developed process technologies, such as the Teniente Type Modified Converter, for copper smelting. Another example is the specific

[1] CIFRAS DE EXPORTACIÓN DE SERVICIOS DE INGENIERIA DE CONSULTA, AIC, Noviembre 2005.

know-how on seismic engineering for industrial installations, aimed to minimize shutdowns after earthquakes.

4. Most of the main local engineering firms are ISO 9001 qualified.
5. The still quite considerable cost advantage. The cost of a Chilean engineer is less than one half of that of an engineer from an industrialized country, and the difference is greater for designers and draftmen, thus resulting in an even lower cost for the integrated engineering team.
6. Improved financial conditions, including an attractive Chilean export credit line for capital goods and engineering.

However, there are still some factors, both in foreign markets and internally, hampering an increased export of Chilean engineering services.

An investigation in 2004 by the AIC identified the following barriers, for international development of Chilean companies (2) :

- Unclear rules of origin.
- Legal restrictions at provincial or state level, that remain although a FTA exists.
- Double taxation.
- Double charge for social security.
- Restrictions in governmental purchases.
- Entry restrictions for professionals or business people.
- Professional registration requirements.
- Certification requirements.
- Cultural barriers.
- Difficulties in obtaining guarantees and insurances.
- Asymmetry in governmental financial and technological support.

The author has also identified the following factors that hamper exports of Chilean engineering services (3):

- Attitudes, among the potential exporters as well as their potential clients.
- Increasing quality requirements, including language skills
- Insufficient market presence and insufficient access to market information and communication networks.
- Lack of government incentives for innovation.
- The absence of equal opportunity.
- An inadequate institutional frame.

A main challenge for the Chilean engineering industry is to go from thinking and talking globally, to acting globally. This is the only possibility of survival and growth in the long term in a country almost completely open to the rest of the world, where foreign investment is as important as local investment. The engineering firms have to invest a lot in confidence-building among their potential clients and convince them that the results they have achieved in Chile can also be repeated abroad. Additionally, the Chilean firms have to invest in internal competence development in order to meet the constantly increasing quality requirements in the highly competitive international market. This competence development should include productivity improvement through increased automation,

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[2] ACUERDOS DE LIBRE COMERCIO DE CHILE Y LA CONSULTORIA, Comité Desarrollo Internacional AIC, Enero 2004.

[3] Development of International competitiveness in industries and individual firms in developing countries: The Case of the Chilean forest – based industry and the Chilean engineering firm Arze, Reciné and Asociados, Elías C. Arze, Börje W. Svensson, International Journal of Producction Economics 52 (1997).

improvement of the working environment, and continuous improvement of human resources through development of technical and marketing knowledge, as well as language skills. These efforts at the individual firm level should be supported by corresponding development efforts at the institutional and governmental levels, in order to secure the industry's recruitment needs of highly qualified personnel in the long run.

The Chilean engineering industry still has a weak presence in the international marketplace. Whether individually, together, or in association with foreign partners, Chilean engineering firms must be constantly present in the marketplace and secure a position in existing communication networks, so that close links can be established to potential clients, partners and competitors.

Although difficult to achieve, Chilean engineering firms should make use of available official and commercial communication channels to propagate for that the principle of equal opportunity is applied in international tendering. The world as it is, is complicated enough for firms from developing countries trying to compete in the international market, and they should therefore be spared from measures that further distort conditions to their disadvantage. Too often proposals are lost against engineering companies from developed countries that offer lower prices than Chilean, thanks to subsidies from governmental aid agencies, presented as technical cooperation between countries.

CHILEAN LEGISLATION APPLICABLE TO WORK OF FOREIGN ENGINEERS

According to the Chilean law, if anyone wants to work in Chile as an engineer, he/she must be in possession of a degree given by a recognized Chilean university or a foreign institution. In the latter case the engineer must revalidate his/her degree at the University of Chile unless favored by any of the agreements for recognition of professions Chile has with several countries. Additionally, the law that created the "Colegio de Ingenieros de Chile" establishes that engineers graduated in third countries, that wish to practice in Chile under a contract and for a limited period of time, must request an authorization from the Colegio de Ingenieros, in which case revalidation becomes unnecessary.

Also, foreign citizens must obtain a visa. Usually visas are given easily to persons that are in possession of a foreign degree, which causes some misunderstanding as frequently engineers think that they are automatically allowed to practice when they obtain the visa, because of having presented their professional certificate. This is incorrect, according to Chilean law.

FREE TRADE AGREEMENTS AND ENGINEERING TRADE

I will refer to the texts of the Free Trade Agreements (FTA's) Chile has with the USA, Canada, Central America and Korea, that are similar among them and similar to NAFTA.

In general terms, these agreements establish that all barriers for commerce are eliminated, except for those stipulated in the annexes, for which, in their majority, progressive suppression terms are settled.

The most common way of providing engineering services is collectively. Collective practice and collective responsibility is seldom recognized in the legislations of the signing countries. Consequently the FTA's make no reference to it. So, regarding the collective practice of engineering, i.e. those services rendered by engineering companies, free trade would be secured by the clauses regarding National Treatment, Most Favored Nation, Free Movement of People and Local Presence, as long as existing barriers for the individual practice of the engineers that belong to these companies, could be overruled.

(The Canada case. An illustrative experience)

Regarding individual practice, I can refer to the only experience the Colegio de Ingenieros and the Asociación de Ingenieros Consultores, in representation of the Chilean engineering community, have, which refers to the Memorandum of Understanding (MOU) signed with our Canadian counterpart, the Canadian Council of Professional Engineers (CCPE), in 2001.

This was a major task due to the enormous differences between the engineering systems existing in Chile and Canada. As a matter of fact the first problem encountered was directly related to our mission as relevant professional body and resides in the text of the agreement, which establishes that the parties shall work "to provide for the temporary licensing in its territory of nationals of the other Party who are licensed in the territory of the other Party". The agreement uses the word license in several parts, which is quite adequate for USA and Canada, where engineers are legally entitled to practice only after having obtained their license, which is given after some years of experience after graduation and passing special examinations, and that must be renewed after a certain number of years. In Chile engineers are formally entitled to practice when they receive their university degree, so licenses, from a formal point of view, are nonexistent. After much analysis, where we even thought that we had to create a licensing system in order to initiate conversations with our Canadian counterpart, this semantic "impasse" was solved by our lawyers, who interpreted the word license as entitlement to practice, condition that is included in the degree given by a university recognized by the Chilean State or in the authorization for temporary practice given by the Colegio de Ingenieros to engineers graduated abroad.

A second problem found refers to the Code of Ethics: The understanding reached by the Northamerican relevant professional bodies, on behalf of NAFTA, showed us how important it was for them the issue of professional ethics and that our code, oriented partly to protect the engineers, required a modernization. Indeed, Annex 2 of the agreement subscribed in 1995 by the North American engineering institutions contains a code of ethics of only 10 points, oriented to protection of the public. The Colegio de Ingenieros (further on "Colegio") undertook the task of revising its code and, by the moment when we started negotiations with the CCPE, we already had a modern code in place.

A third problem encountered relates with the obligation of belonging to a professional institution in order to be able to have a license. In Chile, unlike Canada, it is not necessary to be affiliated to an institution of peers in order to practice. This was an unsolvable obstacle, as the CCPE would only authorize Chilean engineers as long as they belonged in their home country to an institution that would force them to comply with a code of ethics. So, for the moment being, the CCPE would only recognize engineers members of the Colegio, position that could change if the legal frame for the ethic regulation changes in Chile.

A fourth problem found was related with the inexistence in Chile of a system for the accreditation of engineering careers. One of the pillars of Canadian and USA engineering licensing is the existence of a well-developed system for accrediting careers. When the NAFTA professional bodies reached their agreements, Mexico suffered because they did not have such a system in place. As a consequence Mexican engineers were required more years of experience than those required to engineers coming from USA or Canada accredited programs. In Chile we did not have any professional accreditation system and we realized this would be of no benefit to the forthcoming negotiations so we, as professional institutions, promoted the formation of one, task that was undertaken by the Ministry of Education and presently we have a reliable system in place. When we signed the MOU with the CCPE the system was still not operating. Nevertheless, thanks to the prestige of the Colegio de Ingenieros and its longstanding experience in qualifying universities and engineering programs in order to accept new members, as well as on the information obtained by CCPE delegates on the career named "Ingeniería Civil", where "Civil" refers to the depth of the studies rather than the engineering discipline, the CCPE agreed to substitute the lack of a national system by the Colegio procedures.

Finally we had a problem with the different duration between the engineering careers in Canada, generally 4 years, and Chile, between 4 and 6 years. This was not a minor problem and it required an in-depth analysis of the contents of the different careers as well as of the type of professional practice required for licensing in Canada. The result was the acceptance by the Colegio of 4 -years-career licensed Canadian engineers (with 7 years experience) and by the CCPE of Chilean civil engineers (6 years career) with 6 years of experience. Non existence in Chile of institutions similar to the Colegio for careers of 4 or 5 years duration, attempted against their possibilities of obtaining recognition by the CCPE.

These were all major problems that could be solved only thanks to the open attitude of the participants from the engineering institutions of both countries and their willingness to comply with the FTA.

A Memorandum of Understanding (MOU) was signed in June 2001. I will not go into details but just mention that the memorandum established a mutual recognition between the CCPE and the Colegio for accrediting studies and professional experience, and for passing exams, thus enabling engineers to obtain a license from the other country without the need of traveling. Equally important is the recognition as valid of the professional experience in the country of origin.

The MOU was to be ratified a year later. This did not happen because it did not find support from all the Canadian provinces. All the participants have regretted this situation, originated, in my opinion, in the imbalance inherent to a negotiation between two countries so different from an institutional point of view. While in Chile there is a single national authority, in Canada this type of agreement needs to be subscribed by the provincial authorities in order to enforce them. As we have the same situation with USA, we structured the FTA with them a little bit differently, preferring direct negotiations with each one of a selected list of states, instead of negotiations at a central level.

The world follows a trend and we are certain that, sooner or later, conversations with our Canadian counterpart will be reinitiated. In any case we do not regret the outcome of conversations ended in 2001, as the whole process has been of enormous value, not only for the degree of understanding we reached on the barriers existing for engineering practice in Canada and Chile, but for having found feasible ways to facilitate the free flow of engineers between our countries.

CONCLUDING REMARKS

In a world where the greatest contribution to Product is made by the Services Sector, export of services remains to be still emerging, particularly for developing economies, mainly due to the lack of unambiguous procedures, norms and mechanisms for exports. Export of engineering services is no exception, in spite of the recognition and special attention given to it by many economies, mainly developed, due to the important multiplying effect it has on other economical activities.

Chilean consulting engineering is a consolidated services industry thanks to its more than 40 years of continuous development. It represents an activity of more than 300 million USD/year, but more important than that is the fact that it is intimately related to the development of projects that exceed 2 billion USD/year.

Although Chilean engineering exports have been in continuous growth they still represent a very small percentage of the activity, partly due to the difficulties found in an area of the international market that is still very protected locally.

These difficulties are in the process of being recognized by the authorities of the different economies, having incorporated clauses related to services trading in the FTA's, with the support of the private sector.

The main conclusion that can be extracted from this paper is that these efforts must be deepened, not only by our authorities but by a greater participation of the private business world as well.